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The Relation of Pharmacy to Botany*

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INTRODUCTORY

Plants have been used as sources of medicines throughout the history of mankind. In his search for food man discovered early that some plants produced peculiar effects which under certain conditions of ill-health and disease proved beneficial-medicinal plants. These utilitarian aspects were undoubtedly the basic factors which dominated the study of plants and furnished the primary motives for research and investigation in the field of botany. "From the beginning the study of plants has been approached from two widely separated standpoints—the philosophical and the utilitarian. Regarded from the first point of view, botany stands upon its own merits as an integral branch of natural philosophy; whereas, from the second it is merely a by-product of medicine and agriculture."[1] As a matter of fact, until about 1600 botany was primarily studied for the purpose of discovering, describing, and cultivating plants as sources of drugs for use as healing agents. We know that the physician, Valerius Cordus (1515–1544) also one of the pioneers of scientific botany, was influenced by two pharmacists to compile one of the earliest and most important European official pharmacopoeias, and his botanical works were likewise promoted by these two pharmacists; namely, his uncle Rolla, owner of a pharmacy in Leipzig, and Kaspar Pfreund, son-in-law of the famous painter Lucas Cranach, and manager of the latter's pharmacy in Wittenberg.[2] His descriptions of plants are said to exceed all earlier ones in accuracy and definiteness. The historian of botany, E. H. F. Meier, accredits him with an awareness of the differences of species and classes unknown to his predecessors.[3] The Swiss naturalist, Conrad Gessner (1516–1565), who was considered the most scientific botanist of his time, expressly referred to the

* Acknowledgment is hereby made to Dr. Geo. Urdang, Director, American Institute of the History of Pharmacy, Madison, Wisconsin, for assistance in providing material for this paper.

[1] Agnes Arber, Herbals, Their Origin and Evolution, Cambridge 1938.

[2] Herman Schelenz, Geschichte der Pharmacie, Berlin 1904, p. 415.

[3] E. H. F. Meyer, Geschichte der Botanik, Königsberg 1857, 4: 3/20/21.

assistance he was given in his botanical studies by apothecaries, mentioning among others the apothecary, Peter Coudenberg of Antwerp.[4]

PHARMACISTS PROMOTE BOTANY THROUGH BOTANICAL GARDENS

Cultivation of medicinal plants was encouraged through the establishment of botanical gardens. In the establishment and maintenance of these plant gardens pharmacists took an active and important part. The "Jardin des Apothicaire" in Paris was established by the pharmacist Nicolaus Houel in the Sixteenth Century and this was later taken over by the Association of Parisian Apothecaries.[5] The "physick garden" at Chelsea, England was established by the Society of Apothecaries of London in 1673.[6] Both of these are recognized as among the most important institutions of their kind and have contributed immensely to the study of botany. Of such gardens established in more recent times the famous garden of Melbourne, Australia was founded by the pharmacist, Ferdinand Müller. He was also Australia's greatest botanist and his studies of the flora of Australia are recorded in forty volumes which still constitute the fundamental work on this subject.[7]

PHARMACISTS ORIGINATE PLANT CHEMISTRY

Pharmacists were among the first to discover and disclose that the medicinal virtues of plants are due to certain chemical constituents and to engage in research and experimentation in this field. The Swedish apothecary, Carl Wilhelm Scheele, who was the first individual systematically to separate and prepare plant constituents as chemical compounds is regarded as the founder of modern plant chemistry. He isolated a number of acids from plant sources and his methods of procedure are still used by modern scientists and laboratories.[8] The isolation of alkaloids, stimulated by the discovery of morphine and its basic character by the apothecary, Serturner, between 1806 and 1817, was for decades almost exclusively the work of pharmacists. This type of study changed the focus of scientists of that period from the botanical aspects to the study of plant contents, and was responsible for the development of plant chemistry. Investigations in the field of plant chemistry have been extensive and this has now become an important branch of scientific pharmacy.

PHARMACOGNOSY—APPLIED BOTANY

However, the discovery that the medicinal virtues of many plants are

[4] F. A. Flückiger und A. Tschirch, Grundlagen der Pharmacognosie, Berlin 1885, p. 28.
[5] Centenaire de L'école Superieure de L'Université de Paris, 1904, pp. 9, 10.
[6] P. E. F. Perredes, London Botanical Gardens, London 1906, p. 53 ff.
[7] Kremers-Urdang, History of Pharmacy, Philadelphia, 1940, p. 355.
[8] E. Kremers, Phytochemistry, Bull. Univ. Wis. Ser. No. 1732, Gen. Ser. No. 1506 Madison, Wis. 1931, p. 15.

due to chemical constituents, and that these vary with the plant, reemphasized the necessity for authentic and dependable botanical description and identification of such plants and plant material. This, in turn, emphasized and vitalized taxonomy and gave it practical significance. It also stimulated the study of plant anatomy and plant histology. The fact that plants were chemical laboratories encouraged study and research in plant physiology. These constitute some of the fundamental aspects of the subdivision of pharmacy which is now known as pharmacognosy. The motives provided by the utilitarian nature of pharmacognosy have been important and significant factors in broadening the scope and influencing the trends of botanical study and research particularly during the last half century.

PHARMACOGNOSY EXTENDS SCOPE OF BOTANY

Pharmcognosy may be said to have begun with the work of Theodor Martius, an apothecary of Erlangen, Germany.[9] He embodied the results of a series of studies on plant drugs during the period 1825–1832 in a volume entitled "Grundriss der Pharmakognosie des Pflanzenreiches" which is considered the first extensive treatise on pharmacognosy.

Development of histology.—Histological pharmacognosy dates its beginning with the announcement in 1838 by M. J. Schleiden, a German botanist, that the cell is the fundamental unit of plant structure and that all tissues are combinations of cells. In 1847, in an excellent investigation of the rhizome of sarsaparilla he showed pharmacists the usefulness of the microscopical examination of plant drugs. In 1857, Schleiden published one of the early books on pharmacognosy entitled "Handbuch der Medicinisch-Pharmazeutischen Botanik und Botanischen Pharmacognosie." In this book he points out that plant drugs must be identified by their cellular differences.[10] We find also that during this period the Swiss pharmacist, Flückiger (1828–1894) and his English colleague, Daniel Hanbury (1825–1875) published their "Pharmacographia" and many other contributions covering pharmacognostical research. This tradition of combining botanical and pharmacognostical research has been followed by other pharmacists and each has made important contributions, notably Alexander Tschirch (1856–1939), A. Meyer (1850–1922), and L. Guignard (1853–1928).

Alexander Tschirch's voluminous "Handbuch der Pharmakognosie" represents a unique contribution to pharmacy as well as to botany. Tschirch nevered failed to stress his association with pharmacy and his work may well be regarded as a striking example of the relation of pharmacy to botany. Arthur Meyer who, like Tschirch, never failed to stress his close connection with pharmacy, may well be regarded as the outstanding exam-

[9] H. W. Youngken, A Text Book of Pharmacognosy, Philadelphia, 1936, p. 15.
[10] Ibidem.

ple of the relation of pharmacy to botany. The following sentences are quoted from the necrology which his American student, Henry Kraemer, himself an eminent pharmacognosist and botanist, published after Meyer's death in 1922:[11]

Arthur Meyer . . . attained fame in the branches of botany and pharmacognosy. . . . His two volumes on "Scientific Drug Knowledge" are one of the greatest contributions ever made to pharmacognosy. . . . His earlier work on the starch grain was probably equal to Nägeli's master work on the same subject and which was considered by Wallace to be one of the greatest intellectual feats of the last century. . . . His "Handbook of Botany" dealing with the microscopical study of plants, has been very much appreciated by laboratory workers. . . . Starting as a drug clerk he studied under the masters of science and himself became a master and a guide. . . .

Plant cell contents.—It is generally recognized that A. Meyer's studies concerning starch grains and chromatophores laid the groundwork for our present concepts of these significant constituents of plant cells. According to Harvey Gibson, A. Meyer, as early as 1885 "showed that in many plants starch is never formed at all and that such plants produce sugar instead. . . ."[12]

L. Guignard contributed to botanical research by his studies on the origin and structure of the seeds of a large number of plant families. He also made valuable contributions to plant chemistry by his investigations of diastases, glucosides, and plant principles which produce cyanhydric acid in various plants, and the constituents of members of the cruciferous and some other plant families.[13]

It is to be noted that progress and trends in botanical studies were not only influenced by pharmacy but were also reflected in modifications and enlargements of botanical descriptions of plant drugs in the United States Pharmacopoeia. This became particularly significant during the period of agitation for Federal Food and Drug Laws and following the enactment of the Federal Food and Drug Law of 1906. In the earlier editions of the United States Pharmacopoeia, namely, those of 1820 to 1870 inclusive, only a catalog of plant drugs indicating the scientific name and part used was included. The 1880 revision introduced brief botanical descriptions of the unground drug—the part used. The 1900 revision introduced in a few monographs descriptions of the ground drug or powdered drug which included internal structures. In the 1910 revision descriptions of internal structures were considerably enlarged and more generally utilized with more specific and detailed emphasis on cells and cell structures. The 1920 revision introduced the policy of subclassification of botanical descriptions under the subheads, Unground, Structure, and Powder, which policy has been continued in subsequent revisions.

[11] Am. Journ. Pharm. **11**: 984, 1922.
[12] Harvey and Gibson, Outlines of the History of Botany, London, 1919, pp. 215, 238, 239.
[13] Journal Am. Pharm. Assoc. **17**: 613, 1928.

PHARMACY OFFERS PRACTICAL FIELD FOR PLANT PHYSIOLOGY

The use of plants as medicinal agents encouraged and stimulated the study of plant contents, as pointed out above. It was only logical therefore that this should promote study and research concerning plant physiology. Here again it is significant to note the important role of pharmacists in this field of scientific investigation, and the influence of pharmacy in the development of this aspect of botany. One of the greatest plant physiologists of all time, Wilhelm Pfeffer (1845–1920), was closely associated with pharmacy during his early youth and throughout his entire academic career. His father was the proprietor of the only pharmacy in the small town of Grebenstein, Germany, and young Wilhelm grew up in the work and atmosphere of pharmaceutical activity and it was presumed that he would become his father's successor. During his entire academic career he was a teacher and examiner of pharmacists. After having earned his Doctorate Degree at the age of twenty, he returned to his native town and worked for two years as an apprentice in his father's pharmacy. His scientific ambitions, however, urged him back to the University where he engaged in botanical research. In 1881, at the age of thirty-six, he published his fundamental work on plant physiology. The botanist, Haberlandt, stated of this book that "an enormous intellectual achievement is presented in this great work which is unique in the entire botanical literature of all civilized peoples."[14] Harvey-Gibson states that Pfeffer "greatly extended our knowledge of osmotic phenomena" as early as 1877[15] and helped to lay the fundamentals for our present concept of photosynthesis, anabolism, and transport of proteins,[16] of the linking up of respiration and fermentation[17] and of sensitivity and movement.[18]

PHARMACISTS INFLUENCED BOTANICAL STUDIES IN ALL PARTS OF THE WORLD

In all countries of the world knowledge of local floras has been decidedly promoted by practicing pharmacists. In the German and French histories of pharmacy numerous examples are given.[19] It is of special interest that the main work of exploring and describing the flora in the French colonies in

[14] W. Haberlandt, Zum Siebzigsten Geburtstag von Wilhelm Pfeffer, Die Naturwissenschaften, Berlin, 1915.

[15] Harvey and Gibson, l. c., p. 185.

[16] Ibidem, pp. 214, 215.

[17] Ibidem, p. 221.

[18] Ibidem, p. 243.

[19] Herman Schelenz, Geschichte der Pharmacie, Berlin 1904; A. Adlung und G. Urdang, Grundriss der Geschichte der Deutschen Pharmacie, Berlin 1935; L. Andre-Pointier, Histoire de la Pharmacie, Paris 1900; M. Bouvet, Histoire de la Pharmacie en France, Paris 1937.

Algiers, Saint Domingo, Tahiti, etc. was done by French military pharmacists serving in the areas concerned.[20]

PHARMACY PROVIDES MOTIVES FOR BOTANICAL RESEARCH IN AMERICAS

In the Americas, the relation of pharmacy to botany became obvious with discovery and colonization. Botanical research began with the discovery of new vegetable drugs. The works of Nicolas Monardes, Francisco Hernandez, Charles L'Ecluse (Carolus Clusius) and other botanical authors of the 16th and 17th Centuries deal with medicinal plants of the Americas. In these works the plant drugs as such were given at least as much emphasis as the botanical aspects of the plants used as medicinal agents.

Despite the fact that professional pharmacy as an integrated and organized body developed very slowly in North America, it is significant to note that early American pharmacists were also active and productive in botanical research and the relation between pharmacy and botany was duly exemplified and bore fruit on American soil. Upon the death of the Irish born pioneer of American professional pharmacy, Christopher Marshall, Sr. (1709–1797), his biographer called him "an apothecary, druggist, botanist, and chemist."[21] The great American clergyman and botanist, G. H. E. Muhlenberg (1753–1815), consistently sought the advice of apothecaries in his studies concerning "indigenous officinalia."[22] These "indigenous officinalia," as Muhlenberg called the American plants used for medicinal purposes, may be considered as one of the most important incentives for the creation of a Pharmacopoeia of the United States of America at a time when professional medicine and pharmacy were still in the pioneer stages. The American botanist, Benjamin Smith Barton (1766–1815), in his "Collections for an Essay Towards a Materia Medica of the United States" published in 1798 referred to the desirability of giving American drugs "a place in the Pharmacopoeia of this country when such a desideratum shall be supplied."[23] The authors of the Pharmacopoeia of the Massachusetts Medical Society (1808), the forerunner of the Pharmacopoeia of the United States of America, apparently followed the advice of Barton and included a number of indigenous medicinal plants and the Boston Physician, James Thacher (1754–1844), included a greater number in the American New Dispensatory which he published in 1810 as a commentary on the Massachusetts Pharmacopoeia. In 1817–1818 Jacob Bigelow, M.D. "Rumford Professor and Lecturer on Materia Medica and Botany in

[20] M. Bouvet, l. c. p. 394.
[21] Kremers and Urdang, l. c., p. 141.
[22] Ibidem, p. 159.
[23] Reprinted in Bull. Lloyd Libr. 1.

Harvard University" published his famous work entitled "American Medical Botany, Being a Collection of the Native Medicinal Plants of the United States, Containing Their Botanical History and Chemical Analysis, and Properties and Uses in Medicine, Diet and the Arts." Jacob Bigelow also took a prominent part in the preparation of the first United States Pharmacopoeia (1820) serving as one of the five members of the committee appointed to prepare "for the press the National Pharmacopoeia."[24] Wood and Bache in the first edition of their "The Dispensatory of the United States of America" (1833), a commentary on the United States Pharmacopoeia, made it a special point, stressed in the preface, to include "Botanical descriptions of the plants from which the medicines treated of are derived."

A typical American development characterizing the close relationship and interdependence of pharmacy to botany was the so-called "Eclectics" a group of medical practitioners whose materia medica was based fundamentally on the use of vegetable drugs. Several eclectic pharmacies were established in the east and in the middle west and one of them, Boericke and Tafel, Philadelphia and New York, sponsored the publication of Millspaugh's "American Medicinal Plants."[25] The Eclectics, under the inspiring leadership of Lloyd Brothers, John Uri, Curtis Gates, and John Ashley, also sponsored a medical school in Cincinnati, Ohio, for a number of years. The Lloyd Brothers developed a well-known pharmaceutical manufacturing plant devoted to the production of Eclectic Remedies. The fundamental text of this specific medical group was C. S. Rafinesque's "Medical Flora; or Manual of Medical Botany of the United States of North America" published in Philadelphia, 1828–1830. This book was not only an important contribution to pharmacy but also to botany. The book of John Uri and Curtis Gates Lloyd on "Drugs and Medicines of North America" should be noted as one of the later contributions of American Pharmacy to botany.[26] The Lloyd Library developed by Lloyd Brothers and now consisting of over one hundred thousand volumes, and some sixty thousand pamphlets dealing with pharmacy, medicine, and botany, is considered one of the best of its kind in existence.[27]

It has been pointed out that European pharmacists were instrumental in promoting the study of botany by establishing botanical gardens and that as a matter of fact in all countries of the world pharmacists have contributed to the knowledge of the local floras in their respective communities. The same can be said of the pharmacists of the United States. Elias

[24] United States Pharmacopoeia 1820, p. 3.

[25] C. F. Millspaugh, American Medicinal Plants, Philadelphia 1878.

[26] Bull. Lloyd Libr. reprinted 1930 as No. 29, reproduction series No. 9; Vol. 1; Vol. 1, pt. 2; Vol. 2.

[27] Corinne Miller Simmons, The Lloyd Library and Museum—a Brief History of the Founders and its Resources. Reprinted from College and Research Libraries, June, 1941.

Durand (1790–1873), owner of a drug store in Philadelphia, was not only a botanical author of note but collected an herbarium containing over 10,000 species and over 100,000 specimens from all parts of North America. This collection was presented in 1868 to the Garden of Plants Museum, Paris, where "it has been arranged in a special gallery and labelled 'Herba Durand'."[28] Charles Deam, former state forester of Indiana and world renowned botanist, and author of excellent books on the Flora of the State of Indiana, began his career as a pharmacist in Bluffton, Indiana. Joseph E. Harned, proprietor of a pharmacy in Oakland, Maryland, quite recently (1931), published a noteworthy piece of work on "Wild Flowers of the Alleghenies."[29]

Pharmacy continues to provide incentives for study and investigation of heretofore unthought of sources of healing principles from the vegetable kingdom. Witness the spectacular development of antibiotics such as Penicillin, a new connection with botany or more specifically mycology. It has been discovered that several bacteria and molds yield antibiotic substances which have bacteriostatic properties. Their bacteriostatic capacity in vivo may differ quantitatively from that in vitro, hence, their usefulness is limited and varied because of toxicity. Apparently Penicillin, a principle of *Penicillium notatum*, is today the most useful and most important of these antibiotic substances for it is evidently sufficiently non-toxic to be used in vivo.[30] Hence, the unfolding of new vistas showing the interdependence of Pharmacy and Botany goes on and on. Undoubtedly Mother Nature still has many secrets not yet divulged to man but which may be revealed for the benefit of mankind at opportune times. It is our hope that Pharmacy will continue to play as significant a role in the discovery and utilization of nature's resources in the future as it has in the past.

[28] Am. Journ. Pharm. **45**: 508–517, 1873.

[29] K. Scarborough, Botanists Heaped Honors on Maryland Druggist, The Sun, Baltimore, August 3, 1941.

[30] Albert L. Elder, Penicillin, Sci. Monthly **58** (6): 405, June 1944.

The African Oil Palm: Its History, Cultivation and Importance

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Palm oil and palm kernel oil are among the most important vegetable oils imported into the United States. The United States has imported as much as 411 million pounds of palm oil and 179 million pounds of kernels and kernel oil in a single year (1937), after which importations were somewhat interrupted by world conditions. There is apparently a large potential market for these products here. Increased needs for vegetable oils and their valuable by-products should be an incentive to tropical American countries further to develop and exploit the vast stands of oil-producing palms which grow within their borders. It has been authoritatively stated that in Brazil the potential value of the wild babassu palm nut (*Orbignya barbosiana* Burret) crop, alone, is five times the value of the coffee crop (23). The importance of this latter crop in Brazil's economy is common knowledge.

PRODUCT AND ITS SOURCE

The palm oil of commerce is obtained from the oily, fibrous pericarp or outer layer of the fruit of numerous varieties and strains of the African oil palm (*Elaeis guineensis* Jacq.), the "Palmier à huile" of commerce, a member of the coconut family (Palmae). Palm kernel oil is derived from the kernel of the African oil palm seed. This species is one of the few palms which yield a commercial oil from both the pericarp and seed-kernel.

This palm has an erect, thick or slender, simple (rarely branched) trunk, ringed with the successive leaf-scars, and a crown composed of long, spreading, pinnate leaves from whose axils are borne the large, head-like flower clusters. The tree averages about 30 feet in height, but may attain a height of 80 feet, and the trunk is 6 to 15 inches in diameter. The staminate and pistillate flowers are borne in separate inflorescences (called "heads," "cones," or "hands") on the same plant. The oil palm at maturity (about 15 years old), should produce from 6 to 10 heads of fruit each year, but the yield may be as little as 3 heads per year. The heads weigh as much as 35 or more pounds each, and bear on the average several hundred fruits each, although sometimes as many as a thousand fruits are produced. Usually a little more than half of the weight of a head is fruit the remainder being stem and branches. The ellipsoid fruits are pointed at the apex and are 1 to 2 inches long and up to 1½ inches in diameter. When mature, they may weigh from 3 to 25 grams each and are variously colored, being

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yellow, orange, reddish brown or almost black, depending upon the variety, of which there are many. The fruit usually contains only one seed, but 2 or 3 seeds to a fruit are not uncommon. The oil content of the pericarp ranges from approximately 30% to 80%, while the oil content of the kernel is 44% to 53% (19). The proportion of pericarp to the nut is subject to extreme variations, since the seeds of the numerous varieties differ greatly in size as well as in the thickness of their shells.

Palm oil, as it exists in the fresh fruit, is an almost neutral fat, consisting of 10% glycerin, in combination with various fatty acids (6). However, during the extraction from the fruit, some fermentation inevitably occurs and part of the oil is split up into glycerin and free fatty acids, often resulting in a marked acidity in the oil. In the fresh state, the oil is said to be tasty and wholesome.

Hot palm oil is a clear red liquid, which on subsequent cooling deposits a solid. When cooled quickly the oil forms an orange-colored paste, because the solid separates in a very fine state of division. However, when it is cooled very slowly the solid (stearin) separates in a coarse, granular form and sinks, leaving an upper layer of clear red oil (olein). Palm stearin, which includes solidified glycerides of palmitic and stearic acids, etc., is a suitable material for the manufacture of soap and as a source of fatty acid for candles. Palm olein is suitable for direct use as an edible oil. However, refining is usually necessary with a consequent loss of vitamin content. Constants of the whole oil, as produced in British Malaya, are as follows (11): Temperature of total liquification, 40° to 45° C.; iodine value, 50.3 to 52.7; mean molecular weight, 846; free fatty acid content, 4.2%.

According to Jamieson (19), the range of characteristics of palm oil obtained by various observers is as follows: Specific gravity (at 15° C.), 0.9209 to 0.9250; refractive index (at 40° C.), 1.4531 to 1.4580 and (at 60° C.) 1.4451 to 1.4518; saponification value, 196 to 205; saponification equivalent, 268.9 to 279.3; iodine number or value, 48 to 60; unsaponifiable matter, 0.2 to 0.5%; titer, 38° to 47° C. (usually between 42° and 44°).

Palm kernel oil is a white-yellow fat and is similar in physical and chemical properties to coconut oil, with which it is interchangeable for most commercial uses. Unlike palm oil, kernel oil readily becomes rancid.

The characteristics of kernel oil, according to Jamieson (19), are as follows: Specific gravity (at 99°/15° C.), 0.873 and (at 40°/15.5°C.) 0.9119; iodine number, 16 to 23; saponification value, 244 to 255; Reichert-Meissl value, 4.8 to 7; Polenske number, 9.4 to 11; refractive index (at 40° C.), 1.4492 to 1.4517 and (at 60° C.) 1.4430 to 1.4435; titer of fatty acids, 20° to 25° C.; melting point of fat, 24° to 30° C.

USE AND IMPORTANCE

Palm oil is used primarily in the process of manufacturing tin and terne plate, and for making soap and stearic acid. It is used to a lesser degree in

the manufacture of margarine, shortenings, edible fats, candles and lubricating greases, and more recently in the cold reduction process of producing sheet steel. Until recently, palm oil was thought to be indispensable in the tin plating industry, for which purpose the United States uses approximately 30 million pounds annually (7). Bauer and Markley, however, found that hydrogenated cottonseed oil is an excellent substitute for palm oil in the production of tin plate and cold reduced sheet steel (9); in this case, palm oil is no longer indispensable for this purpose.

In West Africa, palm oil is a basic food and for more than 100 years palm oil and kernels have been the chief articles of commerce from this region. The importance of this palm to West Africa is emphasized by the fact that the image of an oil palm tree is embossed upon a coin of British West Africa. For centuries the natives in this part of the world have practiced the extraction of palm oil, and it is extensively used by them for eating as butter, for cooking and as an illuminant and to some extent as an ointment for their bodies. In Brazil, palm oil is used locally in cooking.

According to Buckley (12), unbleached red palm oil may be recommended for culinary or medicinal use on the basis that it contains carotene, the precursor of Vitamin A. Except for its lack of Vitamin D, its potency is such that it could be regarded as a good substitute for cod liver oil. The vitamin activity is not destroyed by ordinary cooking processes. The palatability of the oil has been found to be increased by removing the solid component, and the resulting liquid is richer in carotene than the original whole oil. Since the consistency and melting point of palm oil is near that of butter, it is suitable for the manufacture of margarine. Unlike butter, it has little tendency to become rancid.

Another potential use for palm oil is that of a fuel for engines. Little research has been done in this direction, and methods for use of the oil as a fuel have not been perfected. In 1917 (21), however, experiments were conducted in Belgium in running crude oil engines on low grade palm oil with reported success. Also, in 1922 (20), in the Belgian Congo several river boats were using palm oil as a fuel, at a cost of one-third that of kerosene.

Palm kernel oil may be used in place of coconut oil and is principally used in the manufacture of soap, while glycerin is an important by-product. It is also used in the manufacture of margarine and candy and is used to a limited extent in the manufacture of pharmaceutical and toilet preparations. Palm kernel oil is especially valuable because of its high lauric acid content and glycerin yield, which are equivalent to those of coconut oil. The residual palm kernel cake, after most of the oil has been expressed, is a valuable ingredient of cattle, hog and poultry food. According to Jamieson (19), "The European oil cake contains about 16 per cent protein, 10 of oil, and 38 of carbohydrates, while the extracted meal contains about 2 per cent of oil, 19 of protein, and about 48 of carbohydrates."

According to Dalziel (16), kernel oil is used by the natives of West

Africa for cooking and illumination and for anointing their hair and bodies, and is sometimes mixed with camwood as a medicine for craw-craw, or as a vehicle for other medicines. Among some tribes the making of soap from the kernel oil, along with the ash from various trees, is said to be a considerable industry.

As early as 1909, the meat of the palm kernel was ground and placed on the market by a German firm in Mannheim as "Palmira." This was a hard, snow-white vegetable cooking fat. When mixed with egg-yolk and water it was found to make an acceptable substitute for butter.

In West Africa, the tree, itself, is utilized by the indigenous population in the making of wine, for food and shelter, and in the production of fiber. Fiber is laboriously extracted from the leaves and used extensively along the coast of the Gulf of Guinea for fishing lines and other purposes requiring a fiber of great strength (3). The fiber is not as yet produced in commercial quantities, although it is considered to be one of the most valuable and lasting of tropical fibers.

Dalziel (16) gives an excellent account of the uses made of the oil palm by the West African natives. He writes, "The petioles . . . are used for hut poles and rafters, fences, beds, etc., and are occasionally used for torches. A coarse fibre . . . can be extracted from the outer layer. From the young leaflets a fine fibre of great strength and elasticity is prepared and used for fishing-lines, snares, fine cordage, plaited articles, fly-whisks, strainers, etc., but no economic method of extraction has been devised. A coir-like fibre at the base of the petiole . . . is used as tinder. It was at one time made into a coarse cloth. The midribs of the leaflets are tied up to use as brooms, and the inner portion of the fruit-stalk beaten out makes a short brush used for cleaning the stones used for grinding corn. From the same material in Gold Coast a fibre is extracted and made into hair-brushes and tooth-brushes."

Dalziel also states that the broken shells are put on forest paths as a substitute for gravel, and are beaten into the earthen floor of huts. He notes that "The shell is also polished and carved into ornamental objects or cut into flat beads and rings, the larger sizes worn by women as waist-bands . . . and often regarded as of considerable value, the smaller as armlets and necklaces." The stem is not considered durable and is subject to attack by termites. It is, however, occasionally used for rafters, bridges, fences, etc., and a fiber, which is used for twine, fish traps, strings of musical instruments, etc., is obtained from its base (16). In some parts of Africa the natives use the leaf-stalks to build their houses and barns, and the leaves are used for thatching. Some of the more primitive tribes use the palm fruit as an article of barter. These practical and domestic uses of the oil palm have, to some extent, a direct influence upon the production of oil in these regions.

The large terminal bud, known as "palm-cabbage," is often used as a food. Its removal always results in the death of the tree. The African natives tap the oil palm to obtain the fermentable sap to make palm wine, a beverage with an alcoholic strength of nearly 6%. Usually a deep incision is made in the stalk of the male inflorescence, the immature infrutescence or in the growing point of the palm. In some cases, the tree is felled and tapped below the crown of leaves, the flow of sap being stimulated by fire (16). The wine is said to be commonly used as yeast in making bread. In certain regions of the Ivory Coast the palm is said to be cultivated solely for the wine.

Among the fats and oils imported into the United States, palm oil ranks next to coconut oil in point of volume (9). The world's largest exporters today are European colonial possessions in West Africa, mainly British West Africa (especially Nigeria), the Belgian Congo and French West Africa, with a small amount exported from Latin America, primarily Brazil. Nigeria and the Belgian Congo, alone, have supplied approximately three-fourths of the world's production of palm oil and kernel oil. Before the present war, the Netherlands Indies and British Malaya supplemented greatly the palm oil and kernels imported from West Africa.

In 1931, the United States imported 258 million pounds of palm oil and 39 million pounds of palm kernels and palm kernel oil. Following this there was a steady yearly increase of importations (with minor fluctuations) until a peak was reached in 1937, during which year 411 million pounds of palm oil (valued at about 23 million dollars) and 179 million pounds of palm kernels and palm kernel oil (valued at about 11 million dollars) were imported (28). The bulk of this oil and kernels came from the Netherlands Indies, Belgian Congo and Nigeria. Since 1937, however, there has been a sharp decline in importations, and, in 1939, only 288 million pounds of palm oil and a little more than 2 million pounds of palm kernels and palm kernel oil were imported (29). Considering the steady increase in importations into the United States up to 1937, apparently interrupted by world conditions and not the lack of a market, there should be a large, steady market in the United States for palm oil and kernels after the war.

HISTORY AND DISTRIBUTION OF PLANT, WILD AND CULTIVATED

The African oil palm is today found spontaneously or under cultivation throughout most of the tropics. It occupies a large part of coastal West Africa in a belt up to 300 miles across in some places, from the Cape Verde region in French West Africa, south to below São Paulo de Luanda in Portuguese Angola. Within this region the palm is most productive along the northern side of the Gulf of Guinea from Sierra Leone to the Cameroons (4). It also extends far inland in forested regions where it is found near Lake Tanganyika, on the Zambesi River, and on the west shore of Lake

Nyassa in the south, and northward to the southern frontier of Wadai, Ubangi, the Upper White Nile and the Albert Nyanza. The oil palm is often of local occurrence in some of the Central African regions, and may be of comparatively recent introduction. It is also found sparingly in East Africa in Uganda, Tanganyika and Zanzibar, where it is less productive than in West Africa.

The regions of West Africa where palm oil is produced for commerce include Angola, the Cameroons, Belgian and French Congo, Dahomey, Guinea, Gaboon, Gambia, the Gold Coast, the Ivory Coast, Liberia, Nigeria, Portuguese Guinea, Senegal, Sierra Leone and Togoland.

The oil palm also occurs, either as an introduction or spontaneously, in Brazil, British Guiana, Venezuela, Colombia and the West Indies, especially in regions situated on or near the coast. It has been introduced as an ornament or for food throughout the tropics and subtropics of the world, and in recent years it was being developed very successfully as a plantation crop in the Netherlands Indies (Java and Sumatra), British Malaya and, to some extent, in West Africa and Brazil. It has also been introduced into Ceylon, and Indo- and Cochin-China, but its development has been slow in these places. The oil palm grows well in southern Florida, where it is hardy as far north as Orlando (13). It is known to have been introduced from the Philippines in 1899 and from the Gold Coast in 1902.

The African oil palm was originally thought to be indigenous to West Africa, whence it had been introduced into the Western Hemisphere. In recent years, however, some authors have considered it to be a native of Brazil and an introduction into Africa. As late as 1940, Cook (13) asserted that although the oil palm could have been taken from Africa to the West Indies in the 17th century, an earlier transfer might have been made from Brazil to the Portuguese slave-trading settlements in West Africa. Regardless of its origin, the oil palm is now well-established in Brazil, where man, animals and birds have caused it to become widely distributed.

According to Cook (13), "Palm oil began to figure as a commercial article in the period of the slave trade, that at first was conducted by way of Brazil. Even before the discovery of America, Portuguese missionaries had worked among the natives of the Congo, and the Portuguese colonies in Brazil were the first agricultural settlements in America. The use of the palm oil in Brazil apparently goes back to colonial times."

Although the oil palm was known and utilized for some time before, it was not formally known to science until 1763 when it was described and figured from Martinique by Jacquin (Selectarum Stirpium Americanarum Historia 1: 280; 2: t. 172). Believing that the tree had been introduced from Guinea, Jacquin gave it the specific name, *guineensis*. He also noted that he had never observed it in a wild state in America. In 1767, Linnaeus adopted Jacquin's name in his "Mantissa" (vol. 1:2 1), where he spelled

the generic name as "Elais." The nut and seed were later described and figured (as *E. melanococca* Gaertn.) by J. Gaertner in 1788 (De Fructibus et Seminibus Plantarum, vol. 1: 18, t. 6, fig. 2).

The development of the oil palm as a plantation crop in the East Indies was begun only about 30 years ago. Although it was first introduced into Java and Sumatra in 1848, the oil palm did not receive serious attention until about 1910. It was not until 1918 that attention was directed to possibilities of developing this crop in Malaya (17). Present world conditions terminated an enterprise which had developed by 1935 into an agricultural export industry which ranked fourth in importance in Malaya. Plantations have been developed to a limited extent in West Africa, particularly in the Belgian Congo. Plantation methods have, however, been applied in many regions of West Africa to the vast stands of naturally produced trees which are readily accessible.

HORTICULTURE

In nature, the oil palm is found on a variety of soils. It has been found to grow best in deep, well-drained, moist humus-soils in warm regions of at least 50 inches annually of well-distributed rainfall. It seems to produce equally as well in any region where the rainfall ranges between 70 and 250 inches (4). Because of its sensitivity to drought, however, prolonged dry periods even in a region of abundant rainfall affect the production of oil. The oil palm will not thrive in heavy, swampy or peaty soils, nor is it tolerant of shade. Those palms found growing in dense jungles have been sown mostly by birds or animals and are usually spindly and often sterile. In West Africa, it flourishes in extensive almost pure stands in warm, damp valleys and lowlands, but it may be found on grasslands up to 2,000 feet altitude in the Cameroons, where it still produces fairly good crops (5). The upper limit of the oil palm may be considered to be about 4,000 feet in the Cameroons. At this altitude, however, it does not attain its normal height and development, but it can still be tapped for wine.

The oil palm is said to thrive in Liberia on high, sandy beaches exposed to the sea breeze, or along the coast in gravelly laterite soils around native villages which are more or less permanently located (13). There are an estimated 40 million mature oil palms in Liberia which are said to form forests so dense that production of the fruit is seriously hampered (19). It is thought that Liberia would eventually become an important source of this oil if these forests were properly thinned. In Sumatra, the oil palm will grow inland on gently undulating land and has been planted up to an altitude of 1,000 feet where the same success is met with as in plantations nearer to the sea (24).

Palm oil has for several centuries been a basic food of the natives of West Africa. As an industry, however, it has existed only since about 1790.

and the valuable palm kernel industry did not attract attention until about 1842 (3). Since that time palm oil and palm kernels have become the major export products of West African trade.

In parts of West Africa the natives have practiced a crude form of conservation and plantation procedure. They, as well as animals and birds, have aided the spread of the oil palm by discarding seeds around their villages and along the trails. In the Belgian Congo, the natives are said never to cut a palm tree (20). They make clearings for their crops around trees and then, after several years of cultivation, abandon the area to the palms. This system of shifting cultivation has greatly facilitated the spread of the oil palm in West Africa, and accounts to some extent for the abundance of the palms in secondary forests. To some extent, oil palms are cultivated and protected for palm wine. However, the destructive methods of obtaining the sap by tapping or felling the trees, as practiced in some regions, are not conducive to the production of more oil.

The application of plantation methods to the already existing vast forests of oil palms in West Africa, particularly in the Belgian Congo, began in 1910, about the same time that serious attention was given to establishing plantations in the Netherlands Indies and British Malaya. Large concessions were obtained by business interests in the Belgian Congo and selection and thinning in the groves were undertaken. Trees between the ages of 10 and 20 years were considered the most productive and, consequently, were the ones selected in establishing the groves. Several thousand acres were also planted during this early period, and a steady increase in plantations has continued ever since. Today, there are said to be about 275 thousand acres of oil palms under cultivation in the Belgian Congo (9).

Up to 1942, the Netherlands Indies and British Malaya had developed the plantation system to an extremely productive level. Through a well-planned and scientific program, with its goal the production of palm oil with a minimum of waste and a maximum of quality, these colonies had made rapid progress during the thirty years since oil palm plantations were started. A large part of our horticultural literature concerning the oil palms is the result of experiments and investigations undertaken in these colonies. Experimental plantations have also been set out in various other parts of the tropics, such as the Philippines and Madagascar.

Although the oil palm was introduced into Sumatra in 1848, the impetus to produce oil on an estate scale did not develop until about 1910. By 1932, 155,000 acres had been planted in Sumatra, of which 97,120 acres were fruiting at that time (22), and in British Malaya 61,025 acres had been planted, of which 17,974 acres were producing (7). There is every reason to believe that up to the outbreak of the war thousands of additional acres had been planted and were in bearing.

In establishing oil palm plantations in the East, selection of terrain and

soil corresponding in physical conditions to that in which the palm grows naturally was of the first consideration. In Malaya, an alluvial loam with a clay subsoil was considered to be among the most suitable for growing the oil palm (17), and the palm was found to be at its best on well-drained flats of deep rich soil with abundant atmospheric and soil moisture. The flat coastal areas and areas along certain river banks were found to be suitable if properly drained. Light, sandy soils or swampy soils were considered undesirable and detrimental to the palm.

The entire procedure of propagation and horticultural technique in the treatment of oil palms in Malaya has been so concisely stated by Eaton (17) that it seems best to quote his statement in its entirety, supplementing it where necessary with additional information. This procedure described by Eaton is essentially that used or followed by others in developing oil palm plantations, and is applicable to oil palm plantations wherever they may be.

"The palm is propagated from seed which is planted in suitably prepared nursery beds consisting of nearly pure sand about one foot deep. Ripe fruit only should be selected, and after removing the pericarp (outer fleshy and fibrous layers of the fruit) the nuts should be planted at once just below the surface of the soil. The seed germinates very slowly, even in the case of seed from fresh ripe fruits, so that unless seedlings can be purchased from other estates the preparation of nursery beds and the planting of seed should be one of the first operations on the estates. The nursery beds should be exposed to the sun and kept moist by constant watering.

[Curtler (15) found that germination of oil palm seeds could be expedited and a higher percentage of germination could be obtained by soaking the seeds for one week in warm water or for two days in 1% hydrochloric acid, rinsing afterwards for two days. The majority of viable seeds from 2½ year old palms were found to germinate more quickly than old seeds and those fermented germinate more quickly than untreated seeds.]

"When the two-leaf sheaths appear about the ground, which may not be for two to three months, the seedlings are removed from the nurseries and planted about 1 to 1½ feet apart in another prepared nursery bed on flat land, where they remain until ready for transplanting in the field, which may be from eight to ten months later. [Seedlings are usually planted 30×30 feet apart, giving about 55 trees per acre.] The holes for planting should be dug about 2 ft. square by 2 ft. deep and filled with good surface soil, and the seedlings should be planted so that the base of the leaves is just above the soil surface. The area for several feet around each palm should be forked three or four times per annum. The whole area should either be kept free from weeds or suitable green (leguminous) cover crops should be planted. [Lamtro (*Leucaena glauca* (L.) Benth.) is commonly

grown, with a mixture of *Centrosema pubescens* Benth. and *Pueraria phaseoloides* (Roxb.) Benth. sown between the rows of lamtro.] If the land is clean-weeded and the area is flat and has been cleared of all timber, ploughing and harrowing can be done at intervals.

[Dalziel (16) writes, "The tap-root of the seedlings soon disappears and lateral roots from the bole develop. These form a network of secondary feeding rootlets in the upper layers of the soil which anchors the tree. Adventitious or aerial roots also may develop, and some of the secondary roots develop pneumathodes composed of spongy tissue concerned with aeration so that the palm can withstand submersion."]

" . . . After the palms come into bearing in the third to fourth [sometimes as much as 8 years are needed, depending on the location] leaf pruning is usually carried out by removing the fronds below the bunches of fruit shortly before the fruit ripens. In no case should drastic pruning be adopted since this affects fruit production, and the palms are also liable to be attacked by beetles, resulting possibly in the death of the palm.

"Male and female inflorescences (flowers) are borne by the same palm, but not necessarily at the same time, hence pollination of the female flowers is effected by pollen from the male flowers on other palms—i.e., cross pollination takes place. The female flowers have been proved to be receptive for only two or three days, and only during this period can they be fertilised. Experience in the East has shown that natural pollination [normally by wind] in the case of the young palms often fails, and this has led to experiments on artificial pollination by hand. [Artificial pollination was practiced as early as 1864 in Java.] The pollen is collected from the male flowers by shaking these over a funnel which is held over a suitable receptacle . . . into which the pollen falls. [If kept dry, pollen will maintain its germinating power for 2 or 3 months.] The pollen should be collected preferably in the afternoon and dusted on the receptive female flowers during the following morning. The ripe inflorescences are noted by the distinctive odour of aniseed which is emitted, while the colour and other characters of the female flowers also indicate their receptivity."

Artificial pollination results in a much greater yield, but the process is said to exhaust the trees and impoverish the soil (16). This can be overcome to some extent by manuring and by controlling pollination.

Some experiments have been undertaken to develop improved varieties through natural and scientific selection. This work has been undertaken, however, only in recent years and there has not been sufficient time to obtain definite results. There is little doubt, however, that oil production can be increased through plant breeding to increase the yield of fruits and to raise the oil content of the pericarp and kernels. The palms of West Africa are said to yield fruits with a thin pericarp and thick shell which give relatively a small amount of palm oil and a large amount of kernel oil, whereas those in Malasia yield fruits with a thick pericarp and a relatively

small amount of kernels, thus giving a larger amount of palm oil in proportion to kernel oil (7). The so-called African types are said to be variable as to shape of fruit and thickness of shell and are not constant in inheritance (25). On the whole, the fruits obtained from plantations in Malasia are said to be heavier and richer in oil than those from wild palms in West Africa. This may be considered the result primarily of selective planting in Malasia. It may be, however, the result of climatic differences of the two regions; a very humid type of climate prevails in Malasia where the palm is cultivated, whereas a drier type of climate is prevalent in the region of its native habitat in Africa and also in Brazil. As Dalziel (16) noted, the oil palm " . . . is more luxurious and productive in the equatorial zone than in regions where the dry season is prolonged. In general the yield of oil is more and the proportion of kernel less in climatic conditions approaching the equatorial type, and the reverse in more distinctly tropical conditions of less rainfall with a well-marked dry period."

The desired palm is one that produces a large crop of fruits with a thick pericarp having a high percentage of oil, together with a thin shell and a large kernel of high oil-content.

There is a host of so-called varieties or types of oil palms which bear vernacular and, in some cases, scientific names. The vernacular names are legion since the same type may bear a different name in each country or community where it grows. There is some question as to the taxonomic status of the varietal names applied to the oil palm. There are, however, some few outstanding and well-known types of commercial value. These varieties or types are based, for the most part, on arbitrary characters such as the thickness of the shells, the relative percentage of pericarp and its oil-content, and the relative percentage of kernel and its oil-content. Such a basis for designating varieties can be misleading since the oil-content of the pericarp of fruits from various heads from the same tree can show differences of 20% to 25% (25). It is difficult to determine whether the differences in the types or varieties are the result of genetic influences or are entirely environmental, or both. It is known that oil production is affected by local soil and moisture conditions and it is believed that geographic location may also influence fruit formation and development, with a consequent effect on the quality and amount of oil produced. Jamieson (19), however, suggests that " . . . the variations found in the composition of the oils are due largely to the inherent varietal characteristics of the palms themselves rather than to differences of their environment."

No attempt has been made to evaluate, from a taxonomic standpoint, the large number of proposed varieties or "types" which comprise *Elaeis guineensis*.

Some of the better known accepted varieties of commercial importance and some of their characteristics are as follows:

The "Congo type" ("var. *macrocarya*") is common in the Belgian Congo

and is thick-shelled, the shell being 4–8.5 mm. thick and comprising 50% by the weight of the fruit.

The "Deli type" ("var. *dura*") comprises the bulk of the oil palms grown in Sumatra and to some extent in British Malaya. It has large fruits and is thin-shelled, the shell being 2–5 mm. thick, and comprising 30% by weight of the fruit. The fruit forms are said to be constant by inheritance and the production, measured in weight of fruit heads, is high (22).

The "Lisombé type" ("var. *tenera*") is commonly grown in British Malaya and is thin-shelled, the shell being 1–2.5 mm. thick and comprising 10% by weight of the fruit. This variety is said to be ideal but does not breed true to type and is therefore not safe for plantations (18).

The "Pisifera type" ("var. *pisifera*") has no nutshell and only a small kernel. It is doubtless an abnormality and is not important because of its low yield of fruit

Dalziel states that all four forms can be produced by self- or cross-pollination of palms with "var. *tenera*" (16).

The basis for selection and planting of oil palms should be on the total yield from individual trees of a given variety in a particular region. In this way the variety best suited to a particular region could be found and experiments could then be undertaken to improve it. This entails a long-range program.

Some work has been done on the analysis of the fruits of the oil palm from various regions. Some of these analyses are given below.

The following analysis was made of fruit obtained in Sierra Leone. After having been picked for two days the fruits were placed in cold storage for 25 days before the analysis was made (27): Pericarp, 48.4%—palm oil, 72.93%; moisture, 15.55%; free fatty acid in palm oil (as palmitic acid), 6.86%; Nut, 51.6%—shell, 60.3%; kernel, 39.1%—palm kernel oil, 45.56%; moisture, 13%; free fatty acid in kernel oil (as lauric acid), 00.69%.

According to Eaton (17), the fruit grown in British Malaya has the following average composition: Pericarp, 58%—palm oil, 53%; moisture, 33%; fiber and residue, 14%; Nut, 42%—shell, 85%; kernel, 15%—palm kernel oil, 43%; moisture and residue, 57%; Palm oil in whole fruit, 31%; Kernel in whole fruit, 7%.

According to Geraldes (18), the average composition of some of the varieties grown in Angola is as follows:

"Variety *sempernigra*": Pericarp, 48.87%—palm oil, 46.32%; water, 39.19%; residue, 14.49%; Nut, 51.12%—shell, 77.37%; kernel, 22.62%—palm kernel oil, 42.19%; water, 15.69%.

"Variety *communis* forma *dura*": Pericarp, 51.77%—palm oil, 44.35%; water, 40.29%; residue, 15.36%; Nut, 48.22%—shell, 75.16%; kernel, 24.83%—palm kernel oil, 42.13%; water, 16.59%.

"Variety *communis* forma *tenera*": Pericarp, 71.45%—palm oil, 44.70%; water, 40.53%; residue, 14.77%; Nut, 28.55%—shell, 51.39%; kernel, 48.60%—palm kernel oil, 45.02%; water, 11.50%.

"Variety *macrocarya*": Pericarp, 47.64%—palm oil, 51.82%; water, 33.50%; residue, 15.43%; Nut, 52.35%—shell, 77.81%; kernel, 22.19%—palm kernel oil, 49.06%; water, 6.67%.

"Variety *repanda*": Pericarp, 50.23%—palm oil, 51.94%; water, 36.68%; residue, 11.38%; Nut, 49.76%—shell, 76.24%; kernel, 23.75%—palm kernel oil, 42.68%; water, 14.47%.

"Variety *intermedia*": Pericarp, 73.36%—palm oil, 45.28%; water, 41.62%; residue, 13.10%; Nut, 26.63%—shell, 49.92%; kernel, 50.07%—palm kernel oil, 48.91%; water, 11.06%.

On the east coast of Sumatra the fruit of the Deli type, the large-fruited variety, has the following composition (25): Pericarp, 52%—palm oil, 28 to 29% (the oil of the pericarp averages 16 to 17% of the weight of the fruit-head); water, 24%; residue, 10%; shell, 30%; kernel 7 to 8%; palm kernel oil, 45 to 50%.

The oil palm yields throughout the entire year, there being very few months of the year when a substantial yield of palm fruits is not available. When the palms are intensively cultivated, however, two well-defined fruiting periods become pronounced, aggregating to nearly six months each year (26). In Lagos, Nigeria, the world's greatest palm oil region, the main crop is gathered during the period from February to May.

Forest-grown trees have been found to respond quickly to cultivation provided they are young enough. Trees between the ages of 15 and 30 years, whether forest-grown or cultivated, are considered to be at their prime in the production of oil. Those above 30 years of age should be discarded; the production of oil, however, may continue until a tree is 60 years or more of age, but the decline is noticeably perceptible after the fortieth year.

When oil palms come into full bearing (about the fifteenth year) they produce from 6 to 10 bunches of fruit each year. The yield of oil should amount to at least 2,000 pounds per acre per year and the yield of kernels about 500 pounds per acre per year (17).

In West Africa, the natives usually cultivate their gardens among the palm trees, and in many places where the oil palm is cultivated catch crops are grown. These are usually leguminous plants, among which are French beans and pigeon peas, and also maize and garden produce. In British Malaya, maize, sweet potatoes and groundnuts are commonly cultivated in the oil palm plantations.

In most cases, artificial fertilizing of the soils has been found unnecessary. Belgrave (10), however, found that in Malaya, if the yield of oil was less than 1,500 pounds per acre per year (estimate based on 55 eight year

old trees per acre) on normal soils of an inland type, manuring with phosphatic manures was remunerative. Rock phosphate was found to be as good as basic slag for this purpose. The addition of nitrogen and potash did not seem to be necessary. In Sumatra, the most usual form of manuring was by the use of Cheribon rock phosphate applied annually at the rate of 4.4 pounds per palm, broadcast over the soil (22). Also, in addition to artificial fertilizer, all trash and fruit residues from the factory were returned to the plantations. In most plantations leguminous plants are grown as catch crops or simply to enrich the soil. It has been observed that the productive soils are often poor in lime, phosphate and potash, neutral or alkaline and usually rich in humus.

Excluding damages done to the fruits of young palms by rodents and other animals, cultivated palms have been comparatively free from attack by pests and fungus diseases. However, the rhinoceros or coconut beetle (*Oryctes rhinoceros* L.) and the red-striped weevil (*Rhynchophorus ferrugineus* (Oliv.)) have caused some damage (21). The rhinoceros beetle has been known to cause the death of oil palms (23). In West Africa, a fungus (*Ganoderma* sp.) has been observed to cause trunk rot and the boring beetle (*Oryctes owariensis* Beauv.) has caused some damage (30). Several species of caterpillars (*Psychiae* and *Limacodidae*) have been found on oil palms (24). These might become serious with the planting of larger areas of trees. The grub of the beetle, *Pachymerus nucleorum* of authors, has been found to damage the nuts in British Guiana and Brazil. It is thought by some that the numerous beetles which have been referred to the above name, are a major deterrent to the development of the oil palm in Brazil. The grub of the beetle, *Coelaenomenodera elaeidis* Maulik, has been recorded as attacking the foliage in the Gold Coast, which is said to greatly affect the production of oil. Two scale insects, *Aspidiotus destructor* Sign. and *Ischnaspis filiformis* Dougl., have been recorded as occurring on oil palms in the Seychelles Islands. In Malaya, a little understood rot which affects the fruit-bunches in high-yielding strains has been observed (1). This rot was thought to result from a nutritional disturbance caused by soil deficiency. It was also thought that this nutritional disturbance might either be aggravated or induced by artificial pollination, since this would result somewhat in an artificial dislocation of the nutrient supply. The normal life span of the oil palm is estimated to be somewhere between 100 and 200 years.

HARVESTING AND PROCESSING

The major difficulties encountered in the growing of oil palms on a plantation scale are the gathering and transporting of the fruits and the lack of adequate methods and machinery for extracting the oil from the pulp and for cracking the thick, hard shells in order to obtain the kernels. In some regions, the lack of labor to work the plantations is a problem. In

planning a plantation, a thorough network of communications between all parts of the estate and the factory or factories should be included.

In plantations, oil palms do not at first grow very tall and for the first few years, until the trees are about 12 years of age, it is possible to gather the heads of fruits from the ground. This is seldom true, however, of those trees growing in nature. Since the average height of a tree at maturity is about 30 feet, it is necessary to climb it in order to harvest the fruit. This is the method employed by the natives of West Africa. The African climbs the palm by means of a rope, loop or belt around the tree and himself. With his feet against the tree and his back braced in the hoop he is able to maintain his balance. By throwing his body suddenly forward a little he throws up the hoop and takes a step. This is rapidly repeated until he reaches the top of the palm.

The mature fruit bunches are cut and conveyed to collecting sheds for several days storage in order to complete the ripening of immature fruits or are brought directly to the factory for processing. The fruit, in any case, should not be allowed to ferment since the oil is split up into free fatty acids and glycerin if fermentation occurs. If possible, the fruit should be treated the same day it is harvested because as soon as the bunch is cut, and especially if the fruit has been bruised in any way, the formation of free fatty acids begins, with consequent loss of glycerin.

Palm oil is almost always extracted in the countries of production, whereas the kernels are almost entirely shipped to European countries and the United States where the oil is expressed. The bulk of palm oil is prepared by primitive native methods along wasteful and inefficient lines, and for the most part, is of a quality inferior, because of its high free fatty acid content, to that produced on plantations. The native methods obtain only 7 to 10% of the oil, whereas a modern factory should obtain about 25% (20) or more. The percentage of free fatty acids present in the oil depends on the extent to which fermentation has occurred and is usually an indication of the method by which the oil was prepared, whether by natives or by a modern method (6). Since the freed glycerin, unlike the free fatty acids, is soluble in water, especially if it is hot, and is lost during the extraction of the oil, it is assumed that the free fatty acid content of an oil is inversely proportional to the glycerin content. Therefore, each 10% of free fatty acids indicates a 1% loss of glycerin (6). Oils with a high glycerin content, with a consequent low percentage of free fatty acids, command the highest prices. The lower the free fatty acid content (below 6% is best), the more suitable the oil is for edible purposes.

Different methods of extracting the oil are employed by the natives of West Africa; the methods employed vary in details according to the locality. Fermentation processes are the ones commonly used. In these methods the fruits are first warmed or boiled, or placed fresh in a leaf-lined pit

where, after they are moistened and covered with leaves, they are left to ferment for a certain number of days (usually about 2 weeks) before the oil is extracted from the pulp, which by that time is easily separated from the seeds. The fruits are then removed from the pits and placed in a stone-lined hole and pulverized, after which the crushed fruits are transferred to another hole lined with a mixture of palm oil and wood ashes where the mash is left for about a week. Oil collects in the bottom of the pit. Additional oil is removed by boiling the pulp in water. This fermentation greatly increases the free fatty acid content of the oil produced, sometimes as much as 70% (27). Some natives boil the perfectly ripe fruits, after which the nuts are removed and the pulp is kneaded under water so that the oil floats free on the surface where it is skimmed off and clarified. This method is said to produce a very good edible oil comparable to that produced by modern methods (20), and is much superior to that ordinarily prepared for export.

There are not many instances of adulterations in palm oil. Nevertheless, some adulteration of oil has been practiced on the Gold Coast (2). A peculiar fine, red earth is said to be used for mixing by the middlemen and sometimes over-ripe plantains and sour kanki (*Borassus* sp.?) are mixed with the oil.

Modern methods for the extraction of palm oil involve the use of solvents and the centrifugal and press systems, all of which seem to be efficient although the press system recovers more oil but is said to be more expensive to install. The oil from palm kernels is extracted by solvents or expressed by the use of various types of hydraulic presses, similar to those used for expressing oil from other oil-bearing seeds. Some mills grind the press cake and extract it with solvents for further recovery of oil (19).

The entire head of fruits is usually first heated in hot water or sterilized with steam before the fruits are removed by a threshing machine. Heating or sterilizing the fruits before bruising inactivates the enzymes, which otherwise rapidly split the fat into free fatty acids and glycerin, resulting in an oil unsuitable for edible purposes.

In the press system, as used in Sumatra, the first pressing of the fruits is made under comparatively low pressure (below 100 atmospheres) and yields only oil mixed with a considerable amount of water but otherwise pure. The fruits are then dried in the sun, depulped, heated with steam, and again pressed under high pressure (about 425 atmospheres) in order to remove the remaining 20% of oil. The dried pits are then cracked and the kernels are separated and pressed.

The centrifugal system, as used in British Malaya (17), is essentially as follows: The fruits, after being threshed from the heads, are placed in large cylindrical steamers or kettles and steam-heated for about 15 minutes at a pressure of about 3 pounds above atmospheric. In this way, the fruit is

sterilized, the oil is rendered more fluid and is also partly liberated from the pericarp. The hot fruit is then placed in steam-heated centrifugal machines, similar to those used for extracting sugar from the concentrated cane juice in sugar factories. In these machines, the oil is efficiently separated from the pulp and is then conducted into settling tanks where it is separated from the water and any dirt or trash which may be present. The oil floats on top of the water and is drawn off through pipes into suitable containers. The residual pulp and nuts from the centrifugal machines are then passed through a horizontal cylindrical rotary dryer, which is heated by exhaust gases from the steam-boiler. This treatment almost completely separates the oil-free pulp from the nuts. It is necessary, however, to transfer this mass to rotary sieves in which the complete separation is effected. The fiber is used for fuel in the boilers and the nuts are transferred to nut-cracking machines. After the nuts are cracked the shells and kernels are transferred to a brine bath of suitable density, in which the heavy shells sink and the kernels float. The kernels are then skimmed off in wire baskets and the shells in the bottom of the bath are recovered. Both are transferred to centrifugal machines in which the adhering brine is recovered and returned to the bath. The shells are used for fuel and the kernels are bagged for shipment.

THE OIL PALM IN AMERICA

As noted above, the oil palm is now well-established in the American tropics, especially in Brazil, where it is thought by some authors to be indigenous. It seems quite possible that a plantation system of palm cultivation similar to the Malayan, Sumatran and Belgian Congo developments might be realized in tropical America. In many regions of Central and South America both edaphic and climatic factors are favorable for such a development. The problems of an adequate supply of labor and means of transport should be overcome in time.

Cook (13) advocates the planting of oil palms in Florida, where they will grow well and yield regularly, primarily for the purpose of producing edible oils for local consumption. He also emphasizes the necessity of planting the palms in clumps so as to insure cross-pollination with consequent assured fruit production. It would seem that, considering the lack of large areas of suitable land in Florida, the oil palm could never be grown on a commercial scale in the state. The most feasible plan would be to cooperate with tropical American countries in the development of oil plantations within their domains.

In 1942, a United States Oil Commission (23) investigated, among other things, the possibilities of assisting Brazil to develop the vast stands of oil palms growing in that country. They found that several of the Brazilian States could become large producers of palm oil and palm kernels on a

plantation basis, particularly the State of Bahia, which produced more than 30 thousand pounds of palm oil in 1940. The Commission found that the African oil palm, known as *dende* palm in Brazil, is widely distributed over the State of Bahia, there being an estimated 1,500,000 trees in that State, alone. If this estimate is correct (on the basis of 55 trees per acre as is customarily planted in plantations) there are in Bahia about 27 thousand acres with a potential production capacity of approximately 50 million pounds of palm oil and 13 million pounds of palm kernels annually. Since the trees are doubtless scattered over a vast area which could support the oil palm, thousands of additional acres could probably be planted in Bahia. One plantation observed on Itaparica Island, in Bahia, contained 37 thousand trees and was producing palm oil and kernels. An estimated 300 thousand trees, thought originally to have been introduced from Africa by the Portuguese, grew on the island. The oil palm is thought to have started as a door-yard industry in both Bahia and West Africa. That is, the caboclo (native) in Brazil would plant a few trees in his yard and use the oil for home culinary purposes.

Other coastal States of Brazil, in areas where there is sufficient rainfall, and fertile regions in the interior in the State of Matto Grosso, and in northern Minas Gerais were thought to be equally suitable for the cultivation of the oil palm. However, the ever-present problems of lack of transportation, modern machinery and labor were found to be barriers to overcome in these States.

The Commission strongly recommended that technicians in the United States who were familiar with the plantation development of the oil palm industry in the Netherlands Indies, British Malaya and Belgian Congo be sent to Brazil to work there with the Federal and State governments in ascertaining the localities where the *dende* palm will best flourish and will, therefore, be most profitable when grown on plantations.

The two types of oil palms now used in the plantation development in Brazil are the "sombra" variety, which produces a medium-sized fruit, and the "caboclo" variety, which was developed in Bahia. The latter variety produces an enormous fruit cluster and the individual fruits are said to be as large as a small apple.

The *corozo* palm (*Alfonsia oleifera* H.B.K. or *Corozo oleifera* (H.B.K.) Bailey), of Central America, Colombia and the Amazon region, formerly confused with *Elaeis melanococca* Gaertn. (a synonym of *E. guineensis*), produces fruit that yields both palm oil and kernel oil, similarly to the African oil palm. It is said to be tolerant of shade and grows in marshy places, swamps and on wet clay soils. This being the case, this species might supplement *Elaeis*, which cannot tolerate these conditions, with the result that an undulating country with poor drainage might be completely utilized for palm plantations. The fruit is said to consist of 16% pulp, 62%

shell and 22% kernel, and the pulp to contain about 30% of an orange semi-liquid oil (19). In Panama, small use is made of the oil of the *corozo* palm in cooking and eating, and to some extent as a medicine, hair tonic, illuminant and leather softener.

Vast stands of additional oil-producing palms occur in the wild from Mexico to southern Brazil. The full value of this great natural wealth and resource is not yet fully recognized. With the rise of new and greater needs for vegetable oils and an increasing market, it should not be long before commercial production of these oils reaches a much higher level than ever before.

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The Taxonomy of the Mexican, Central American and West Indian Species of Ouratea (Ochnaceae)

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The history of the Mexican, Central American, and West Indian species of the arborescent genus *Ouratea* revolves mainly about the work of four authors: Engler (American species), Urban (Antillean species), van Tieghem, and Riley (Mexican, Central American and West Indian species). While Engler in his treatment (2), described several species and made numerous combinations, his correlation between the North American species and the South American species is particularly interesting. Van Tieghem (7), in his monograph of the Ochnaceae, elected to divide the genus *Ouratea* into thirty-four genera, describing ten species from North America. Unfortunately his descriptions of species are poor, with undue emphasis on anatomical characters. In this paper I am reducing to synonymy seven of these species. Urban in his *Symbolae Antillanae* (6), in addition to a fine bibliographical survey, includes numerous combinations of van Tieghem's species; I have retained two of the six species proposed by Urban. Riley's more recent treatment (4) of the Ourateae is well-balanced although few specimens are cited. Since Riley's survey, three species have been described by Britton, all of which I am reducing to synonymy, and three species proposed by Standley, one of which I am retaining. If the fifty-five specific names in current use for the North American species of the Ourateae, twenty-six are valid, one is deserving of varietal rank, three are doubtful because of inadequate description and lack of material, and twenty-five are invalid. I am describing two new species in this paper.

Planchon (Hook. Lond. Bot. **6**: 12. 1847) sums up well the difficulty one has in studying the genus *Ouratea:* "Les différences spécifiques sont, dans ce genre, si difficiles à rendre par des mots qu'il est souvent impossible d'arriver à des déterminations sûres d'après de simples descriptions." Worthwhile floral differences other than that of the relative size of parts, are rare. The shape, size, and secondary venation of the leaf-blades and the habit and size of the vegetative portions of the inflorescence serve to distinguish the Ourateas vegetatively. Stipules and bracts rarely persist and are of little practical importance in a taxonomic study of the genus. While the size and shape of the fruit provide workable characters, few fruiting specimens are available for study; those specimens which have mature fruit usually lack drupes; the torus which persists, frequently provides key-characters. I have constructed my key to species in view of these facts but I do not consider the key to be a natural one. Success with the key depends mainly on the condition of the inflorescence of the material to be keyed.

Three terms which occur in the key and which refer to the habit of the inflorescence are illustrated by photographs of representative collections of the species: *hemispherical* (Fig. 1, *O. laurifolia*), *arborescent* (Fig. 2, *O. elegans*), and *pyramidal* (Fig. 3, *O. insulae*). I have also included a fourth figure: the rarely collected *O. jurgensenii* (Planch.) Engler.

The Mexican, Central American, and West Indian species of *Ouratea* range from lianas to tall trees. *O. insulae* Riley may attain a height of 25 meters. As a rule, however, the Ourateas are small trees or shrubs. As is characteristic of the majority of the genera of the Ochnaceae, the lustrous leaf-blades of *Ouratea* tend to be grouped and to persist at the apices of the twigs, thus giving the plants an attractive appearance.

Baillon (1) notes that the concoctions of the roots of the Antillean species, *O. ilicifolia*, are described as "amères, stomachiques, digestives, antivomitives." Engler (Mart. Fl. Bras. **12**(2): 366–367. 1876) states as much for the same species but he fails to mention any other species of *Ouratea* as being medicinally important. He does assert, however, that many of the Ourateas have properties similar to those ascribed to the genus *Quassia*. Roig (Dicc. Bot. 844–845. 1928) lists the common names of five Cuban species: "Cordon de soldado" (*O. ilicifolia* (DC.) Baillon), "Orilla de arroyo" (*O. alaternifolia* (A. Rich.) Maza), "Guanabanilla de monte" (*O. nitida* (Sw.) Engler), "Rascabarriga" (*O. elliptica* (A. Rich.) Maza), and 'Guanabanilla" (*O. revoluta* (C. Wright) Engler. Several collectors have listed common names on their labels. Gentle's collection (*526*) of *O. nitida* from British Honduras bears the common name "wild corkwood." In Dominica, according to Valeur's label on his collection *858*, *O. ilicifolia* is commonly known as "chicharon." Harris' collection of *O. jamaicensis* (*9071*) is labelled "cabbage bark." Duss labels his collection of *O. longifolia* (3243) as "coffee-wood," while Fishlock notes that a species well-known in Porto Rico, *O. litoralis* is termed "bedstead-wood." Two collectors assign three different names to *O. insulae:* von Hagen and von Hagen (*1313* and *1397*) note the common names 'Urado" and "Buhki," while Lundell (*6369*) appends "chilillo-che." Bartlett (12631) records a variation this last name, viz., "Utop-chiliche," on a collection of *O. insulae*. On another collection in British Honduras Bartlett (*12240*) records the common name "Ixpambul" for *O. guatemalensis*. Several names are assigned to *O. guildingii:* "Bois cafe" (*Duss 1383*), "Bois cagnette" (*Duss 3689*), and "Picquanier" (*L'herminerii* without number). According to Standley (5) *O. mexicana* is known in Mexico as "Cinco Negritos" or "Zapotillo de la Costa."

The geographical distribution of the Mexican, Central American, and West Indian species of *Ouratea* is presented in tabular form (Table 1).

No attempt is made in this paper to redescribe the species studied, except those which are new or have not been adequately described. I have elabo-

TABLE 1. *The Distribution of the Mexican, Central American, and West Indian Species of Ouratea.*

	Mexico	Guatemala	Honduras	Brit. Hond.	Nicaragua	Costa Rica	Panama	Cuba	Haiti	Dom. Republic	Jamaica	Porto Rico	Antigua	Monserrat	Guadeloupe	Dominica	St. Lucia	St. Thomas	St. Vincent	Trinidad
1. *O. purdieana*																				x
2. *O. ligans*						x														
*3. *O. nitida*	x		x	x				x			x									
4. *O. globosa*	x																			
*5. *O. curvata*							x													
6. *O. tuerckheimii*		x																		
*7. *O. gigantophylla*		x																		
8. *O. mexicana*	x						x													
9. *O. ilicifolia*								x	x			x								
10. *O. laurifolia*								x			x									
11. *O. jamaicensis*											x									
12. *O. elegans*											x									
13. *O. longifolia*															x	x				
14. *O. revoluta*								x												
15. *O. litoralis*												x						x		
16. *O. elliptica*								x												
17. *O. alternifolia*								x												
18. *O. striata*								x				x								
19. *O. pyramidalis*	x	x					x													
20. *O. valerii*						x														
21. *O. insulae*		x	x	x																
22. *O. jurgensenii*	x																			
*23. *O. lucens*							x													
24. *O. guatemalensis*	x	x	x	x			x													
25. *O. madrensis*	x																			
26. *O. podocarpa*							x													
27. *O. prominens*						x														
*28. *O. guildingii*							x				x		x	x	x	x	x		x	x

* These species are found outside of the limits discussed in this paper.

rated on several of Riley's original descriptions which, while lengthy, are not always satisfactory.

The author wishes to thank the Directors of the institutions listed below who were kind enough to allow him to examine herbarium material of *Ouratea*. For purposes of citation a letter designating the particular institution is used:

Field Museum of Natural History, Chicago, Ill. (F).
Gray Herbarium, Cambridge, Mass. (G).
New York Botanical Garden, New York, N.Y. (NY).
United States National Herbarium, Washington, D.C. (US).

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read the manuscript, and to Fleda Griffith of the New York Botanical Garden who made the photographs.

KEY TO SPECIES

Floral bracts persistent until late anthesis.................................... 1. *O. purdieana*
Floral bracts not persistent until late anthesis.
  Secondary veins of leaf blades insculptate or impressed on upper surface.
    Leaf blades up to 15 cm. long; bases of leaf blades not crowded and contiguous at apices of twigs.
      Leaf blades coriaceous; pedicels $1\frac{1}{2}$–2× longer than buds.................. 3. *O. nitida*
      Leaf blades submembranaceous; pedicels 3× longer than buds........... 4. *O. globosa*
    Leaf blades 20–40 cm. long; bases of leaf blades crowded and contiguous at apices of twigs.
      Lowermost branches of panicle 1–10 cm. long; Panama.................. 5. *O. curvata*
      Lowermost branches of panicle 10–20 cm. long; Guatemala.
        Pedicels longer than the oblong-ovoid buds....................... 6. *O. tuerckheimii*
        Pedicels shorter than the ovoid buds......................... 7. *O. gigantophylla*
  Secondary veins of leaf-blades obviously not insculptate or impressed.
    Leaf blades spinose-margined.. 9. *O. ilicifolia*
    Leaf blades obviously not spinose-margined.
      Rachis of inflorescence pluriramose, the branches obvious, the inflorescence either hemispherical in shape or arborescent in habit of branching or obviously pyramidal-paniculate in shape.
        Inflorescence either hemispherical in shape or arborescent in habit of branching.
          Inflorescence hemispherical in shape (5–9 cm. long, 6–8 cm. wide), densely flowered; fruit narrow-oblong (3× as long as wide).................. 10. *O. laurifolia*
          Inflorescence obviously not hemispherical in shape; arborescent in habit of branching; fruit oblong or rotund (up to 2× as long as wide).
            Ovary short stipitate; leaf blades up to 15 cm. long; Jamaica.
              Secondary veins of leaf blades prominulous beneath; leaf blades oblong-lanceolate... 11. *O. jamaicensis*
              Secondary veins of leaf blades prominent beneath; leaf blades narrow-lanceolate... 12. *O. elegans*
            Ovary long-stipitate; leaf-blades 20–40 cm. long; Dominica and Guadeloupe.... .... 13. *O. longifolia*
        Inflorescence a terminal pyramidal-panicle; West Indian and Central American.
          Leaf blades 6–9 cm. long; West Indian.
            Buds 6–7 cm. long.
              Margins of leaf blades distinctly revolute; apex of some leaf blades retuse; Cuba.. 14. *O. revoluta*
              Margins of leaf blades not distinctly revolute; apex of leaf blades not retuse; Porto Rico, St. Thomas............................. 15. *O. littoralis*
            Buds 4–5 mm. long.
              Pedicels at anthesis 8–15 mm. long; inflorescence densely flowered; torus of fruit about 5 mm. long.................................... 16. *O. elliptica*
              Pedicels at anthesis 4–8 mm. long; inflorescence few-flowered; torus of fruit about 10 mm. long.
                Leaf blades elliptic or oval, obtuse at apex............... 17. *O. alaternifolia*
                Leaf blades lanceolate, linear-lanceolate or ovate-lanceolate; short-acuminate at apex.. 18. *O. striata*
          Leaf blades 10–50 cm. long; Central American.
            Leaf blades finely serrate.............................. 19. *O. pyramidalis*
            Leaf blades not finely serrate.
              Inflorescence with numerous flowers, the basal branches 10–25 cm. long, the rachis 3–5 mm. wide at base.
                Leaf blades obtuse at apex; branches of inflorescence arcuate-ascending.... .... 20. *O. valerii*

Leaf blades acute or acuminate at apex, the branches of inflorescence subhorizontal or angular-ascending........................21. *O. insulae*

Inflorescence few-flowered, the basal branches up to 5 cm. long, the rachis 1–1.5 mm. wide at base............................22. *O. jurgensenii*

Rachis of inflorescence not obviously pluriramose, the flowers usually fasciculate, the clusters appressed to the simple rachis or rarely on short branches.

Secondary veins of leaf blades prominent beneath................27. *O. prominens*

Secondary veins of leaf blades not prominent beneath (although frequently prominulous).

Rachis bearing short stiff patent branches from which the flowers are quickly deciduous, the bare branches resembling spines................8. *O. mexicana*

Rachis either simple or bearing short branches which obviously do not become spine-like.

Rachis solitary at the tips of the twigs.

Leaf blades 8–10 cm. long; buds consistently 0.9–1 cm. long; rachis, peduncles, and pedicels obviously granulose........................23. *O. lucens*

Leaf blades 8–16 (usually 12–16) cm. long; buds 4–7 mm. long; rachis, peduncles, and pedicels obviously not granulose.

Buds 4–6 mm. long, those 6 mm. long about 4.5 mm. wide at base, obtuse to acute at apex.

Flowers solitary (or infrequently fasciculate in pairs) on a non-erect rachis.

Buds subacute at apex; tree.....................24. *O. guatemalensis*

Buds very acute at apex; liana........................2. *O. ligans*

Flowers fasciculate on short peduncles (the inflorescence often subpaniculate), the rachis erect or angular-ascending.........25. *O. madrensis*

Buds about 7 mm. long, 3.5 mm. wide at base, subacuminate at apex...... ....26. *O. pedocarpa*

Rachises several at the tips of the twigs.....................28. *O. guildingii*

1. OURATEA PURDIEANA van Tieghem, Ann. Sci. Nat. VIII. **16**: 263. 1902.
Gomphia nitida Grisebach, Fl. Brit. W. Ind. 105. 1859. Not Sw.

Twigs smooth, olive-gray or gray-black when dry, lustrous; leaf-blades well spaced near apices of twigs, drying brown, the petioles 0.5–1.5 cm. long, the surface cracking transversely, stiff and thin-coriaceous, often curled and inaequilateral, oblong-lanceolate, 8–20 cm. long, 3–6 cm. wide, tapering (often widely) into a deltoid point or short acuminate at apex, cuneate or subrotund at base, the costa smooth, lustrous above and below, prominent above, subprominent or subplane below, the lateral veins arcuate-ascending, immersed above and below (seemingly more so beneath), of these 12–20 passing regularly to margin, the margin slender-callose, serrate, the teeth patent and argute (especially toward apex of blade), distinctly falcate, often incurved, 0.5–1 mm. long, about 1–3 mm. apart toward base (frequently absent toward base); inflorescence terminating the twigs as a patent terminal panicle, up to 25 cm. long, often 20 cm. wide, the rachises solitary or as many as three arising from the axils of the uppermost leaf-blades, 3–5 mm. wide at base, smooth, angular (especially toward apex), the branches frequently triquetous, whorled, subplane, the lowermost 3–13 cm. long, 1–2 cm. apart, arcuate or angular-ascending; bracts ovate-oblong, 3–4 mm. long, acute, the margin irregular; buds ovate, up to 6 mm. long; sepals narrow-ovate, 5–8 mm. long, about 2.5 mm. wide,

tapering narrowly into an acute point, obtuse to subrotund toward base; petals obovate-rhomboid or obovate, about 5.6 mm. long, 5.2 mm. wide, obtuse at apex, widely cuneate at base; anthers sessile, linear, about 4 mm. long; ovary about .8 mm. long, the style subulate, about 3.2 mm. long; fruit marcescent, drying black, the torus compressed-rotund, up to 7 mm. long, 10 mm. wide, usually broader than long, the pedicels ascending, often slightly curved, 7–10 mm. long, the drupes not seen.

Type Locality: Trinidad, West Indies.

Distribution: Known only from Trinidad.

TRINIDAD: Lucutche, *Dannouse 6739* (NY); *Purdie* s.no. (F, frag., NY, type collection).

Van Tieghem failed to give an adequate description of this species and in view of this I am giving a complete one.

While the veins of the leaf-blades of *O. purdieana* are insculptate on both surfaces (not merely on the lower surface as van Tieghem states (loc. cit.)), and thus give evidence of its relationship with *O. nitida* (Sw.) Engler, *O. purdieana* is readily distinguished from all of the North American species of *Ouratea* by the bracts which persist until late anthesis, with the exception of *O. insulae* to which it seems closely related. I could not ascertain from the few flowers available for dissection whether the petals are shorter than the sepals. Although *Dannhouse 6739* (NY) is a mature fruiting specimen, no drupes were available for examination, having fallen from the persistent torus.

2. **Ouratea ligans** Dwyer, sp. nov.

Liana; petiolis brevibus subcrassatis saepe horizonaliter gracili-striatis (circ. 5 mm. longis); laminae gracili-coriaceae vix tortae oblongo-lanceolatae, 4–8 cm. longae, 1.5–3 cm. latae, basi cuneatae apice angusto-acuminatae costa utrimque subprominente venis lateralibus, alibus (circ. 10 distinctis) prominulis utrimque et eis circ. 1 cm. distantibus arcuato-ascendentibus mox parallelibus margini et eventualiter consocie vene exteriore anastomosis, alibus numerosissimis prominulis aut (minoribus) subimmersis irregularibus crebris non argute ascendentibus margine vix revoluto argute serrato supra medium dentibus subfalcatis, 1.5–2 mm. distantibus; stipulae deciduae supra-axillares longitudine striatae lanceolatae-subulatae; inflorescentiae terminales floribus solitariis aut in fasciculis racemosis in 1–2 rachides porriginosos virgas terminantibus bracteis pluribus (hic evidenter in gemma olim rhachides tectis) persistentibus crebris in circitu dispositis longitudine gracili-striatis ovato-lanceolatis vel lanceolato-sublatis ad 3.5 mm. longis; gemmae distincte conicae, circ. 5.5 mm. longae, basi 3 mm. latae, apice acutae, pedicellis gracilibus nigris in siccitate saepe granulosis curvatis ad 1 cm. longis; sepala angusto-ovata, circ. 8.5 mm. longa, 2.5–3 mm. (basi) lata, ad apicem angusto-attenuata basi

obtusis venis circ. 10 erectis vix ramosis; petala flava obovato-rotunda obovata vel oblonga, 7–10 mm. longa, 5–6.7 mm. lata, apice obtusa vel rotunda basi obtusa vel subspatulata venis numerosis gracilibus flabellatis; antheris linearibus, 6–6.5 mm. longis, inverse S-figuratis; ovarium stipite 0.5–1 mm. longo, circ. 1 mm. longum, 1.5 mm. latum, stylo crasso-subulato, 4.5–6 mm. longo ad apicem, attenuato; fructu non viso.

Type Locality: San Pedro de San Ramõn, Alajuela, Costa Rica.

Distribution: Known only from the type locality.

COSTA RICA: Alajuela: San Pedro de San Ramõn, *Brenes 3606* (F, type).

O. ligans differs from all of the Mexican, Central American, and West Indian species of *Ouratea* in being a liana; from this character the species derives its name. Its general foliar character, in addition to the size and the habit of the inflorescence, points to its close relationship with the complex species *O. guatemalensis*. The conical and markedly acute buds offer an excellent character distinguishing it from this species.

3. OURATEA NITIDA (Sw.) Engler in Mart. Fl. Bras. **12**(2): 310. 1876.

Ochna nitida Sw. Prodr. 67. 1788.
Gomphia nitida Vahl, Symb. **2**: 49. 1791.
Gomphia acuminata A. Rich. Ess. Fl. Cub. **10**: 139. 1845.
Gomphia magdalenae Hemsl. Biol. Centr. Veg. Bot. **1**: 176. 1879.
Ouratea cubensis Urban, Symb. Ant. **1**: 363. 1899.
Trichouratea nitida (Sw.) van Tieghem, Ann. Sci. Nat. VIII. **16**: 235. 1902.
Ouratea panamica van Tieghem, Ann. Sci. Nat. VIII. **16**: 263. 1902.

Type Locality: Jamaica, West Indies.

Distribution: Known from Mexico, British Honduras, Honduras, Cuba, Jamaica, and British Guiana.

MEXICO: Chiapas: Río Leche, *Mell 2028* (NY); Tabasco: Balancan, *Matuda 3804* (NY); Campeche: Irtubide, *Flores* s.no. (F); BRITISH HONDURAS: Without definite locality, *Gentle 526* (NY); *Record* 4 (F); Stann Creek: *Gentle 2967* (NY); *Schipp 193* (NY); Belize District: *Gentle 99* (NY). HONDURAS: Yoro: Tela, *Chickering 45* (F). CUBA: Without locality, *Wright 2115* (NY); Pinar del Río; Río Guao, *Britton, Britton,* and *Cowell 9640* (NY); El Jiqui, *Roig* and *Cremata 2146* (NY); Laguna Jovero, *Shafer 10834* (NY), *10845* (NY); Santa Clara, Cienfuegos, *Combs 171* (?) (NY); Ciénaga de Zapata, *Leon* and *Loustalot 9510* (NY); Oriente: Loma del Gato, *Leon, Clement,* and *Roca 10836* (NY); Isle of Pines: without definite locality, *Taylor 100* (NY); Los Indios, *Britton, Britton,* and *Wilson 14795* (NY); San Juan: *Britton, Britton,* and *Wilson 15526* (NY); *Roig* and *Cremata 1816* (NY); Santa Barbara, *Earle* s. no. (NY); Nueva Gerona, *Jennings 214* (NY); Managua, *Palmer* and *Riley 1100* (NY). BRITISH GUIANA: Arubaru River, Mazaruni River, *Pinkus 277* (NY).

O. nitida is characterized by oblong-lanceolate leaf-blades with the secondary veins clearly insculptate below. The inflorescence is pyramidal-paniculate; in representative material it does not exceed the leaf-blades in length; the flowers are borne on elongate pedicels.

I must agree with Riley (loc. cit.) in the reduction of *O. cubensis* Urban to synonymy, despite the fact that nearly all of the material from Cuba bears this name.

4. OURATEA GLOBOSA Engler in Mart. Fl. Bras. **12**(2): 323. 1876.

Type locality: Lizando, Michoacàn, Mexico.

Distribution: Known only from the type locality.

MEXICO: Michoacàn: Lizando, *Wavra 273* (F, photo of type).

I am retaining this species despite the fact that some of the important specific characters are indeterminable in the photograph of the type, viz., the membranaceous leaf-blades and impressed secondary veins of the leaf-blades. Membranaceous leaf-blades among the Ourateas are rarely found in the species within the range treated in this paper. Engler's description of the leaf-blades of *O. globosa* as acute at the base is inaccurate since at least one leaf of the type specimen is obtuse at the base.

O. globosa is related to two species: *O. subscandens* (Planch.) Engler, a species known from Brazil, Dutch Guiana, and British Guiana, and to the well-known and widely distributed *O. nitida* (Sw.) Engler. It resembles both these species in having the secondary veins of the leaf-blades insculptate, in leaf-blade shape, and especial relationship to *O. nitida* is manifested in its distinctly globose drupes. Unfortunately the fruit of *O. subscandens* has not been described. *O. globosa* differs from *O. nitida* in possessing membranaceous leaf-blades and a compressed inflorescence which does not exceed the uppermost leaf-blades in length.

5. OURATEA CURVATA (St. Hil.) Engler in Mart. Fl. Bras. **12**(2): 306. 1878.

Gomphia curvata St. Hil. Fl. Bras. Merid. **1**: 69. 1825.
Ouratea crassinervia Engler in Mart. Fl. Bras. **12**(2): 337. 1876.
Ouratea costaricensis Standl. Mus. Nat. Hist. **18**(2): 694. 1937.

Type Locality: Itapacorá (?), Brazil.

Distribution: Known from Costa Rica, Isla de Colón, Panama, and Brazil.

PANAMA: Bocas del Toro, Isla de Colón, *Woodson*, *Allen*, and *Seibert 1948* (F). BRAZIL: Itapacorá (?), *Pohl* (?) s. no. (F, photo and frag. of cotoype collection); *Herb. Vindob.* (F, photo of cotype collection.)

Engler made the combination *O. curvata* in his key to the species rather than in the text. Unfortunately in the same text one finds *O. crassinervia* described as a new species following the numeral corresponding to the numeral designating *O. curvata* in the key. Examination of type material of *O. crassinervia* leaves no doubt that it is conspecific with *O. curvata*.

6. OURATEA TUERCKHEIMII J. D. Smith in Bot. Gaz. **23**: 294. 1902.

Type Locality: Cubiliquitz, Alta Verapaz, Guatemala.

Illustration: J. D. Smith in Bot. Gaz. **23**: *pl. 10, f. 1–10*, 1902.

Distribution: Known only from the type locality.

GUATEMALA: Alta Verapaz: Cubiliquitz, 350 m. alt., *Tuerckheim 378* (NY).

Tuerckheim's collection is from the type locality and in every detail matches J. D. Smith's original description. The immersed secondary veins of the leaf-blades, while arcuate-ascending, do not ascend very sharply. There is no doubt that *O. tuerckheimii* is related to *O. gigantophylla*.

7. OURATEA GIGANTOPHYLLA (Erhard) Engler in Mart. Fl. Bras. **12**(2): 338. 1876.

Gomphia gigantophylla Erhard, Fl. **32**: 250. 1849.
Gomphia theophrasta Lind. Cat. **14**: 8. 1859.
Wolkensteinia theophrasta (Erhard) Regel, Gartenfl. **14**: 131. 1865.
Ouratea theophrasta (Lind.) Baillon, Hist. Pl. **4**: 359. 1873.

Type Locality: Brazil.

Illustration: Hook. in Curtis' Bot. Mag. f. *5642* as *Gomphia theophrasta*, 1867; L'Hér. in Hortic. Fr. **21**: 15. f.1., 1864; Regel, Gartenfl. **14**: 131. f. 471, as *Wolkensteinia theophrasta*, 1865.

Distribution: Known from the State of Alta Verapaz, Guatemala and from southeastern Brazil.

Although I have not seen material of this species, I propose to retain it since it has been well described in the literature. Riley (loc. cit.) elected to segregate *O. theophrasta* from *O. gigantophylla* on the grounds that the type collections of the two species were made in widely separated areas, i.e., Guatemala and Brazil, and secondly that they differ in stipule shape.

The genus *Wolkensteinia* Regel is known to have been described from abnormal flowering material.

8. OURATEA MEXICANA (H. and B.) Engler in Mart. Fl. Bras. **12**(2): 312. 1876.

Gomphia mexicana H. and B. Pl. Aequin. **2**: 21. 1809.
Ouratella mexicana (H. and B.) van Tieghem, Ann. Sci. Nat. VIII. **16**: 289. 1902.
Ouratea pallida Standl. Contr. U. S. Herb. **23**: 820. 1923.

Type Locality: Acapulco and Chipancingo, Chiapas (or Guerrero), Mexico.

Illustration: H. and B. Pl. Aequin. **2**: *pl. 74*. 1809.

Distribution: Known from Mexico and Panama.

MEXICO: Oaxaca: *Mell 2263* (NY); Chiapas or Guerrero: Chipancgo, *Humbolt* and *Bonpland* s.no. (F, photo and frag. of type collection of *Gomphia mexicana*); Acapulca, *Palmer 412* (NY); Acaponeta, Tepic, *Rose*, *Standley*, and *Russell 14445* (NY, type collection of *O. pallida*); Las Tres Mariás, Maria Madre, *Nelson 4238* (F). PANAMA: Penonome, *Williams 353* (NY).

Llewelyn Williams (collection *9698*) gives elucidating field notes concerning this species: "Armed shrub or small tree . . . Crown spreading with numerous branches. Trunk short . . . leaves leathery; fruit black when mature; calyx cup pale yellow; twigs armed with spines up to 1 inch long." Actually the "spines" mentioned by Williams are the short strict rachises of the inflorescence from which the flowers are soon deciduous after anthesis.

9. OURATEA ILICIFOLIA (DC.) Baillon, Hist. Pl. **4:** 366. 1873.

Gomphia jabotapita Sw. Fl. Ind. **2:** 740. 1798. Not Linn.
Gomphia jabotapita DC. in Ann. Mus. **17:** 418. 1811. In part.
Gomphia ilicifolia DC. in Ann. Mus. **17:** 418. 1811.
Ouratea spinulosa Urban, Symb. Ant. **1:** 362. 1899.
Camptouratea spinulosa (Urban) van Tieghem, Ann. Sci. Nat. VIII. **16:** 214. 1902.
Camptouratea ilicifolia (DC.) van Tieghem, Ann. Sci. Nat. VIII. **16:** 214. 1902.
Camptouratea agrophylla van Tieghem, Ann. Sci. Nat. VIII. **16:** 214. 1902.
Ouratea plumieri van Tieghem, Ann. Sci. Nat. VIII. **16:** 256. 1902.
Ouratea jaegeriana Urban, Symb. Ant. **5:** 425. 1908.
Ouratea agrophylla (van Tieghem) Urban, Symb. Ant. **5:** 426. 1908.
Ouratea lenticellosa Urban, Repert. Sp. Nov. **18:** 366. 1922.

Type Locality: Dominica, West Indies.
Distribution: Known from Cuba, Haiti, Dominica, and Porto Rico.

CUBA: Without locality: *De Candolle* s.no. (F, photo of type collection of *Gomphia ilicifolia*); *Wright 2117* (NY); Pinar del Río: Sierra de Cabra, *Britton, Britton*, and *Cowell 9798* (NY); Los Palacios, *Shafer 11911* (NY); Sumdiéro, *Shafer 13451* (NY); Habana, *Leon 2045* (NY); San Antonio, *Shafer 214* (NY); San Antonio, *Hitchcock* s.no. (F); San Antonio, *Curtis 684* (NY); San Antonio, *van Hermann 815* (NY); San Antonio de los Baños, *Abarca 4771* (NY); Playa de Marianao, *Britton* and *Wilson 4510* (NY); Loma de Ramirez, *Leon 9720* (NY); Santa Clara: Without locality, *Luna 473* (NY); Punta Diabolo, *Britton* and *Wilson 572* (NY); Loma Cruz, *Britton, Britton*, and *Cowell 10226* (NY); Cienfuegos, Milpa, *Jack 5119* (NY); Sabana de San Marcos, *Leon 9205* (NY); Motembo, *Leon, Edmund*, and *Fortun 8575* (NY); Camagüey: Without locality, *Shafer 867* (NY); Sierra Cubitas, *Shafer 490* (NY); Camagüey, *Britton, Britton*, and *Cowell 13249* (NY); *Britton 2363* (NY); Oriente: Manazanillo, *Combs* s. no. (NY); Holquin, *Shafer 1284* (NY). HAITI: Dept. du Nord: St. Michel del'Atalaye, *Leonard 7556* (NY). DOMINICA: San Gabriel, *Abbott 1242* (NY); Samaná Peninsula: *Abbott 2294* (NY); Mongon, *Valeur 858* (NY). PORTO RICO: Viegues: Cucarache, *Curbela X79* (NY).

O. ilicifolia is the easiest species of *Ouratea*, within the range treated in this paper, to recognize since the leaf-blades are spinose-margined. Both Urban and van Tieghem elected to describe their species principally on the variation of the marginal toothing; they failed however to give worthwhile floral, fruit, and inflorescence differences.

9a. **Ouratea ilicifolia** (DC.) Baillon var. **savannarum** (Britton and Wilson) Dwyer, comb. nov.

Ouratea savannarum Britton and Wilson, Bull. Torrey Club **48:** 342. 1921.

I do not consider the reduction in the marginal toothing and the width of the leaf-blades sufficiently strong characters to warrant retaining Britton and Wilson's species. It seems, however, to be deserving of varietal rank.

10. OURATEA LAURIFOLIA (Sw.) Engler in Mart. Fl. Bras. **12**(2): 350. 1876.

Gomphia laurifolia Sw. Fl. Ind. **2:** 741. 1798.
Ochna laurifolia Kuntze, Rev. Gen. 106. 1891.

Type Locality: Jamaica, West Indies.
Illustration: Rendle and Fawcett, Fl. Jamaica **5:** 175. *pl. 66, a–d.* 1926.
Distribution: Known only from Jamaica and Cuba.

Fig. 1. A photograph of typical material of *O. laurifolia* showing the hemispherical shape of the inflorescence.

CUBA: Pinar del Río: Cayajabos, 400 m. alt., *Leon 13817* (NY). JAMAICA: Without locality: *Macfayden* s. no. (G); Cherry Garden, *Harris 5513* (NY); Plato, *Harris 5535* (NY); Holly Mount, *Harris 8898* (NY); Peckham Woodland, Upper Clarendon, *Harris 10870, 10875* (NY); Constant Spring, *Harris 11919* (NY); St. Andrew, *Harris 10104* (NY).

O. laurifolia is a shrub 3–5 m. in height; collections indicate that it is restricted to altitudes of 400–700 meters. Characters distinguishing this species, are: the small buds, subrotund in shape, averaging 3 mm. in length, the multi-flowered inflorescence with the flowers disposed on the slender pedicels of the secondary branches. The inflorescence is arborescent in habit with the bifurcations of the branches distinct; in addition the inflorescence is disposed as a semi-circle which scarcely (or obviously not) exceeds the uppermost leaf-blades in length (cf. Fig. 1). *Harris 10875* (NY) which has mature fruit, permits us to elaborate on Engler's original description of "drupis globosis." Here the drupes are not globose but narrow-oblong or narrow-obovate and measure about 1 cm. in length and 0.4 cm. in width; the surface of the drupes (1–2 per torus) is longitudinally striate and glistening black in color; the torus is subrotund and about 0.3 cm. in length.

11. OURATEA JAMAICENSIS (Planch.) Urban, Symb. Ant. **1**: 362. 1899.

Gomphia jamaicensis Planch. Hook. Jour. Bot. **6**: 11. 1847.
Gomphia guianensis A. Rich. Griseb. Fl. Brit. W. Ind. 105. 1859. In part.
Ouratea guianensis Aubl. ex Engler in Mart Fl. Bras. **12**(2): 314. 1876. In part.

Type Locality: Jamaica, West Indies.
Distribution: Known only from Jamaica.

JAMAICA: Troy, Cockpit Co., *Britton 609* (NY); Troy, *Harris 9071* (NY); Hollymount, *Harris 6529* (NY); Peckham Woods, Upper Clarendon, *Harris 10999* (NY).

The patent secondary branches of the inflorescence which are arborescent in their manner of branching and the elongate pedicels of the flowers point to the fact that *O. jamaicensis* is related to *O. elegans* Urb. and *O. longifolia* (DC.) Engler. It differs from both of these species in having the secondary veins of the leaf-blades prominulous and not prominent beneath, and in having a short-stipitate ovary.

12. OURATEA ELEGANS Urb. Symb. Ant. **5**: 428. 1908. Rev. spelling of *elaegans*.

Type Locality: Woodstock near Beaufort, Jamaica.
Distribution: Known from Jamaica and Venezuela.

JAMAICA: Woodstock, *Britton 1564* (NY); Woodstock near Beaufort, *Harris 9912* (NY, cotype collection). VENEZUELA: Lower Río Orinoco, *Rusby* and *Squires 447* (NY).

I consider this species to be distinct from *O. jamaicensis* to which it is closely related. Not only is the inflorescence larger and more patent, but the flowers are borne on much more slender pedicels, likewise the leaf-

FIG. 2. A photograph of typical material of *O. elegans* illustrating the arborescent branching of the inflorescence.

blades are typically salicoid (in the two Jamaica collections). *Rusby* and *Squires 447* (NY) has a fragmentary inflorescence but in general the plant seems referable to *O. elegans*. The leaf-blades are atypical, being broader and having a serrate margin. Although Rusby and Squires do not list the locality of this collection, their adjacent collection numbers indicate that it was probably made at Santa Catalina, Delta Amacuro, lower Rio Orinoco, Venezuela.

13. OURATEA LONGIFOLIA (DC.) Engler in Mart. Fl. Bras. **12**(2): 316. 1876.

Gomphia longifolia DC. Ann. Mus. Paris **17**: 417. 1811.

Type Locality: Guadeloupe, West Indies.
Illustration: DC. Ann. Mus. Paris **17**: *t. 10, f. a–l*, 1811.
Distribution: Guadeloupe, French Guiana, and in British Guiana (Engler loc. cit., including var. *microcalyx* Engler).

GUADELOUPE: Bois de Gommier, *Duss 3243* (G, NY); Bois de Gommier, *Stehlé 1280* (NY); Sofaya above Ste. Rose, *L. R. Holdridge 439* (NY).

The texture, size, and venation of the leaf-blades of this species show its relationship with *O. guianensis* Aublet, the type species of the genus. The leaf-blades, on the other hand, are obtuse to subcordate at the base. The inflorescence of *O. longifolia* is few-flowered with the fascicles borne on slender irregular branches while the inflorescence of *O. guianensis* is many-flowered, the fascicles being borne on rigid and arcuate-ascending branches. Its loose inflorescence-pattern indicates that it is in part related to *O. elegans*.

14. OURATEA REVOLUTA (C. Wright) Engler in Mart. Fl. Bras. **12**(2): 346. 1876.

Gomphia revoluta C. Wright in Griseb. Mem. Acad. XI. **8**: 166. 1860.
Ouratea xolismaefolia Britton and Wilson, Bull. Torrey Club **50**: 52. 1923.

Type Locality: Oriente, Cuba.
Distribution: Known only from the Province of Oriente, Cuba.

CUBA: Oriente: Without definite locality, *Wright* s.no. (G, NY, type collection of *Gomphia revoluta*); Sierra Maestra, 1000 m. alt., *Ekman 14244* (NY); Sierra de Nipe, 725 m. alt., *Ekman 12514* (NY); High Maestra, *Leon 10911* (NY, type of *O. xolismaefolia*).

Comparison of the type collections of *O. revoluta* and *O. xolismaefolia* leaves no doubt that the two are conspecific. Outside of differences in the color (when dry) and in the size of the leaf-blades, the division into two species is apparently unwarranted.

15. OURATEA LITORALIS Urban, Symb. Ant. **1**: 363. 1899.

Gomphia nitida DC. Ann. Mus. Paris **17**: 419. 1811. Not Sw.

Type Locality: Porto Rico.

Illustration: DC. Ann. Mus. Paris **17**: *pl. 13, f. m–o*, 1811.

Distribution: Known only from Porto Rico and St. Thomas, West Indies.

PORTO RICO: Without locality: *Holdridge 458* (NY); Locality obscure (Serpentine), *Velez 1121* (NY); Virgin Gorda, *Fishlock 307* (F, NY); Laguna Tortuguero: *Britton, Britton*, and *Boydton 8234* (NY); *Britton* and *Chardon 6841* (NY); *Britton, Cowell*, and *Brown 3843* (NY); Arecibo: Vega Bajo: *Heller* and *Heller 1318* (NY); *Underwood* and *Griggs 928* (NY); Mayaguez: Guanajibo, *Britton 4354* (NY); Susúa, *Holdridge 3* (NY); San German, *Palmer* s. no. (NY); San Juan: Río Piedras, Fuica, *Hioram* s. no. (NY); Río Piedras, *Stevenson 2149* (NY); Miraflores, *Morss 2* (G); Humacao: Playa de Fajardo, *Britton* and *Shafer 1564* (NY); Fajardo, *Liateus* s.no. (G); Fajardo, *Sinten 913* (G, NY).

O. litoralis is a well-defined species, apparently confined to Porto Rico and to the Island of St. Thomas. Although closely related to the Cuban species, *O. revoluta* is distinguished by its larger and acuminate leaf-blades which are scarcely revolute on the margin. The prominulous secondary veins of the leaf-blades have a characteristic reticulation which cannot be adequately described. In addition, the leaf-blades have a distinguishing color when dry.[1]

16. OURATEA ELLIPTICA (A. Rich.) Maza, Anal. Soc. Esp. Hist. Nat. **23**: 45. 1894.

Gomphia elliptica A. Rich. in Ess. Fl. Cub. **10**: 140. 1845.
Gomphia pinetorum C. Wright in Griseb. Cat. Pl. Cub. 37. 1845.
Camptouratea elliptica van Tieghem, Ann. Sci. Nat. VIII. **16**: 214. 1902.
Ouratea pinetorum (C. Wright) van Tieghem, Ann. Sci., Nat. VIII. **16**: 257. 1902.

Shrub (1 m. high?); petioles crassate, about 3 mm. long; twigs drying gray-brown or black; leaf-blades often distichously arranged, stiff-coriaceous, oblong, oblong-rotund to sublanceolate, 2–10 cm. long, 1–4 cm. wide, obtuse (round or narrowly so) at apex, cuneate to obtusely truncate at base (rarely subcordate), frequently inaequilateral, the costa prominent beneath, subprominent above (plane in middle and at base), the secondary veins prominulous (or rarely immersed above), forming a conspicuous reticulum above, the veins of two kinds, some (7–10) arcuate-ascending as they leave costa, then sharply ascending and usually irregular or branching toward margin, the lowermost vein often paralleling margin of leaf-blade to middle before evanescing, the others (very numerous) prominulous or rarely immersed, crowded, forming a dense and conspicuous reticulum, the margin entire, scarcely revolute; stipules deciduous; inflorescence terminal or disposed on terminal axillary branches, compressed-paniculate or patent-paniculate, the rachis shorter than or exceeding uppermost leaf-blades in length, rubescent, angular, the basal branches (when inflorescence patent) subhorizontal, subarcuate or angular-ascending, 2 3 cm. long, 0.7–1 mm. wide, 0.3–1.5 cm. apart, the flowers very dense, solitary or fasciculate, the pedicels lax, 8–15 mm. long, 0.3–0.4 mm. wide; buds ovate,

[1] Cf. Ridgway's "Color Standard and Color Nomenclature," *pl. 15*, color-hue *17*, tone *k* (Dresden-brown), 1912.

4 mm. long; sepals oblong or ovate-oblong, unequal in length, 5–6.5 mm. long, 2.5–2.8 mm. wide (not flattened), obtuse at apex and base, the veins numerous, erect, branching; petals yellow, inaequilateral, 6–7.5 mm. long, 6–9 mm. wide, often wider than long, obovate-rotund, retuse or round-obtuse at apex, spatulate to widely cuneate at base; anthers linear, about 6 mm. long, 1 mm. wide at base; stipe of ovary about 0.5 mm. long, the carpels about 6 mm. long, the ovary 0.75–1 mm. long, the style 4–5 mm. long; torus obovate to rotund (or compressed-rotund), about 5 mm. long; drupes not seen.

Type Locality: Cuba.

Distribution: Known only from Cuba.

CUBA: Without definite locality, *Wright 2116* (G, type collection of *Gomphia pinetorum*), *2118* (NY); Pinar del Río: Without definite locality, *Cuesta 653* (NY); Las Gras, *Britton 10039* (NY); Herradura, *Earle 658* (NY); Arroyo Mantua, *Ekman 10988* (NY); Pinares, *Leon* and *Charles 4878* (NY); San Diego de los Baños, *Leon* and *Charles 4879* (NY); Río Viñales, *Cuesta 444* (NY); *Leon 14346* (NY); Isle of Pines: La Canada, *Britton, Britton* and *Wilson 14403* (NY); Nueva Gerona, Curtiss 377 (NY); Los Indios, Jennings 325 (NY); Hato Nuevo, *Roig* and *Cremata 1800* (NY).

17. OURATEA ALTERNIFOLIA (A. Rich.) Maza, Anal. Soc. Esp. Hist. Nat. **23**: 46. 1894. Emended spelling.

Gomphia alaternifolia A. Rich. Ess. Fl. Cub. **10**: 139. 1845.
Ouratea alternifolia (A. Rich.) Engler in Mart. Fl. Bras. **12**(2): 339. 1876.
Cerouratea alaternifolia (A. Rich.) van Tieghem, Ann. Sci. Nat. VIII. **16**: 277. 1920.
Camptouratea alaternifolia van Tieghem, Jour. Bot. **16**: 192. 1902.

Type Locality: Habana, Cuba.

Distribution: Known only from Cuba.

Although I have not seen any material of *O. alternifolia*, I have included this species in the paper because of the differences which Urban lists (loc. cit., **5**: 427); he cites several characters which distinguish it from *O. striata:* its elliptic or oval leaf-blades which are obtuse at the apex and are strongly coriaceous (3.5–5 cm. long, 1.3–2.5 cm. wide), the characteristic venation of the leaf-blades, its larger flowers with sepals 7 mm. long, and lastly its subquadrate anthers. It is interesting to note that Urban does not cite any specimens of *O. alternifolia*. The differences mentioned by Urban have been gleaned from Richard's and van Tieghem's original descriptions.

18. OURATEA STRIATA (van Tieghem) Urban, Symb. Ant. **5**: 427. 1908.

Camptouratea striata van Tieghem, Ann. Sci. Nat. VIII. **16**: 422. 1902.
Ouratea affinis Britton, Mem. Torrey Club **16**: 87. 1920.
Ouratea roigii Britton, Mem. Torrey Club **16**: 82. 1920.

Shrubs or trees, 3–8 m. high; twigs waxy-gray, the surface frequently cracking, often angular; petioles 3–9 mm. long; leaf-blades coriaceous, often curled when dry, lanceolate, linear-lanceolate or ovate-lanceolate, 4–11 cm. long, 1.5–3.5 cm. wide, acute or short-acuminate at apex, cuneate or cuneate-rotund at base, the costa prominent above and below, the

secondary veins of two sorts, some (4–8 per side) prominulous and leaving the costa at a 70°–80° angle, immediately arcuate-ascending and eventually paralleling the margin, the lowermost vein joining the vein above at or about the middle of the blade, gradually evanescing, others (very numerous) subprominulous, subhorizontal, pluriramose and forming a dense reticulum, the margin distinctly revolute; stipules deciduous; inflorescence terminal or axillary at apices of twigs, usually both types present on one specimen, pyramidal-paniculate, patent or compressed, the lowermost branches frequently less than 1 cm. long, the flowers seemingly racemosely disposed, or when inflorescence patent, the basal branches frequently measuring up to 3 cm. in length, 0.7–1.3 cm. apart, angular-ascending or frequently subhorizontal, the rachis and its branches often triquetous or plane, the flowers solitary or fasciculate on a short sympodium, the pedicels slender, 4–8 mm. long; buds oblong-rotund to rotund, about 4 mm. long at maturity; sepals elliptic-oblong, about 5 mm. long, 2.7–3 mm. wide; petals obovate, 5–6 mm. long, 4–4.5 mm. broad; anthers linear, 3.5–4 mm. long; stipe of ovary about 1 mm. long, the ovary about 1.5 mm. long, 1 mm. wide, the style falcate, about 3 mm. long, somewhat crassate at base; torus in fruit obovate, about 1 cm. long at maturity, 0.5–0.6 mm. wide (toward apex), the drupes drying lustrous-black, irregular-striate, obovate-oblong, obviously inaequilateral toward base, 0.8–1 cm. long, 0.6–0.8 cm. wide.

Type Locality: Monte Verde, Oriente, Cuba.

Distribution: Known only from the Province of Oriente, Cuba, and from Porto Rico.

CUBA: Oriente: Sierra de Nipe, *Ekman 5012* (NY), *9696* (NY), *9915* (NY), *Shafer 3564* (NY); Monte Verde, *Hioram* and *Manuel 3829* (NY); Monte Verde, *Wright 58* (NY, type collection of *Camptouratea striata*); La Prenda, *Hioram* and *Manuel 4745* (NY); Yateras, *Maxon 4176* (F, NY); Cañete, *Roig 67* (NY, type of *O. Roigii*); Río Naranjo, *Shafer 3869* (NY, type of *O. affinis*). PORTO RICO: El Yunque, *Horne* s. no. (NY); Cayey, *L. E. Gregory 80* (NY).

This is the first critical description of *O. striata*, a species closely related to the almost exclusively Porto Rican species, *O. litoralis*. *Gregory 80* (NY) is an excellent fruiting specimen and the only one in fruit which I have seen.

19. OURATEA PYRAMIDALIS Riley, Bull. Kew 107. 1924.

Type Locality: Atasta, Tabasco, Mexico.

Distribution: Known from Mexico, Guatemala, and Panama.

PANAMA: *Hayes 506* (NY).

The single specimen cited above is one of the three listed by Riley (also cf. loc. cit. 364). It matches his description perfectly. Although *O. pyramidalis* is obviously related to *O. guatemalensis*, it is readily distinguished by the argutely dentate margin of its leaf-blades, with the teeth approximate and extending to the base of the lamina, and by its very patent panicle.

20. OURATEA VALERII Standl. Field Mus. **18**: 694. 1937.

Type Locality: Playa Blanca, Golfo Dulce, Costa Rica.

Distribution: Known only from the type locality.

COSTA RICA: Playa Blanca, Golfo Dulce, *Valerio 435* (F, type collection).

O. valerii possesses the largest leaf-blades among the Central American and West Indian species of *Ouratea*, reaching up to a half a meter in length and up to 15 cm. in width. Coupled with the large leaf-blades is an equally large inflorescence with alternate angular arcuate-ascending branches, the latter bearing well-spaced (1.5–2 cm. apart) flowers along their length. The secondary veins of the leaf-blades are prominulous; this character readily distinguishes it from three long-leaved species to which it is related: *O. curvata*, *O. tuerckheimii*, and *O. gigantophylla*. A study of the large-leaved Ourateas of the Old World and New World seems necessary to establish the specific relationships within this complex.

21. OURATEA INSULAE Riley, Bull. Kew 106. 1924.

Gomphia nitida Hemsl. Biol. Centr. Veg. Bot. **4**: 111. 1887. Not Sw. (1788).

Trees 12–25 m. high; twigs round in cross section, smooth, ashen-gray; petioles 0.7–1 cm. long, 1–3 cm. apart; leaf-blades well spaced toward apex, lustrous, coriaceous, yellow-brown or brown when dry, oblong-lanceolate or narrow oblong-lanceolate, 12–31 cm. long, 3.5–8 cm. wide, cuneate or round-obtuse at base, acute at apex, often short-acuminate, the costa prominent above, often subplane above base, prominent and longitudinally striate beneath, the secondary veins of two kinds, some (25–50) distinctly prominulous, arcuate-ascending, paralleling the margin for a distance and eventually passing into a marginal tooth, others (very numerous) crowded, irregular, immersed or prominulous, scarcely ascending, the margin serrate (except entire for 2–3 cm. at base (or not infrequently up to middle)), the teeth often subfalcate, 0.3–2.5 cm. apart; inflorescence strictly terminal, pyramidal-paniculate, the rachis stout, 3–5 mm. wide at base, 9–22 cm. long, usually not exceeding the uppermost leaf-blades in length, angular, contorted, usually becoming caudate and lax toward apex, the basal branches 6–13 cm. long (averaging 11 cm. in length), 1–2.5 cm. apart, becoming progressively shorter toward apex, the upper quarter of rachis simple, the branches subhorizontal, often somewhat deflexed, angular or arcuate-ascending, the flowers fasciculate on a short sympodium or on compressed tertiary branches, the pedicels granulose (often distinctly so), slender, 7–10 mm. long 0.5 mm. wide, swollen toward apex; bracts persistent, ovate, 1 mm. or less long, acute, curled; sepals subcarnose, dorsally marcescent-rugose (especially toward apex), linear-ovate, 6–7.5 mm. long, 2–2.8 mm. wide at base, acute at apex, obtuse at base, the veins 3 or more, well-spaced, ascending, erect; petals yellow, obovate-spatulate, 8.5–9 mm. long, 6–7.5 mm. wide, inaequilateral and bilobed, rotundate and often

FIG. 3. A photograph of typical material of *O. insulae* showing the characteristic pyramidal-shaped panicle.

retuse in the middle, subspatulate at base, the veins subflabellate, the median veins (or vein) somewhat more conspicuous or immersed in the white thick claw; anthers sessile, linear, 5–6 mm. long; stipe of pistil 0.5 mm. long, the ovary about 1.2 mm. long, the style subulate, about 5.5 mm. long, attenuate at apex; pedicels (of fruit) bright red (in vivo), curved, 6.5–8.5 mm. long, 0.75 mm. wide in middle; torus drying dull red-black, obovate-oblong to rotund, 5–10 mm. long, the drupes inaequilateral, plump oblong-rotund, up to 9 mm. long, up to 8 mm. wide.

Type Locality: Ruatan Island, Honduras.

Distribution: Known from British Honduras, Honduras, and Guatemala.

BRITISH HONDURAS: Temash River, *Schipp S 652*; Camp 33, B. H. Guatmala Survey, 800 m. alt., *Schipp 1239* (NY); El Cayo: Vacca, *Gentle 2459* (NY); Valeatin, *Lundell 6296* (NY), *6369* (NY). GUATEMALA: Peten: Tipal, *Bartlett 12631* (NY); Vera Paz and Chiquimula: *Sereno Watson 75* (G). HONDURAS: Colon: Garunta, Wispernini Camp, *von Hagen* and *von Hagen 1397* (NY).

O. insulae, a species of the rain-forests and river-banks apparently attains the greatest height of any of the Mexican, Central American, and West Indian species of *Ouratea*. It has been frequently confused with *O. pyramidalis*. I have elected to redescribe this species because Riley based his original description on but one collection.

Two collections listed above are worthy of special note: *Gentle 2459* (NY) has buds and pedicels which are granulose in appearance to the naked eye; the second, *von Hagen* and *von Hagen* 1397 (NY), the only collection which I have seen from Honduras, has its leaf-blades narrowly deltoid toward apex and has much shorter buds; the secondary branches of the inflorescence are strongly angular-ascending. While in these points the plant appears different, I cannot convince myself that this collection is worthy of consideration as the basis of a new species.

22. OURATEA JURGENSENII (Planch.) Engler in Mart. Fl. Bras. **12**(2): 351. 1876. Emended spelling of Engler's comb.

Gomphia jurgensenii Planch. Hook Jour. Bot. **6**: 11. 1847.
Notouratea recurva van Tieghem, Ann. Sci. Nat. VIII. **16**: 220. 1902.

Type Locality: Mexico.

Distribution: Known only from two collections in Mexico.

MEXICO: Without locality: *Jurgensen 779* (F, photo and frag. of type); Oaxaca(?): Chinantla, *Galeotti 7243* (F, NY).

This is a sharply defined species with salicoid well-spaced leaf-blades with prominulous secondary veins. Especially striking is the terminal inflorescence with its very slender rachis bearing 1-3 equally slender subhorizontal branches, 2–4 cm. apart; the flowers are few and are borne on very slender and lax pedicels which measure about 1.5 cm. in length.

FIG. 4. A photograph of *O. jurgensenii* [collection by Galeotti (*7243*) (F)].

23. OURATEA LUCENS (H.B.K.) Engler in Mart. Fl. Bras. **12**(2): 350. 1876.

Gomphia lucens H.B.K. Nov. Gen. & Sp. **7**: 1825.
Ouratea isthmica Riley, Bull. Kew 108. 1924.

Type Locality: El Zapote, 360 m. alt., Colombia.
Distribution: Known from Panama and northern Colombia.

PANAMA: Bohio Soldado, *Cowell 220* (NY); Gatum, *Hayes 466* (NY). COLOMBIA: El Zapote, *Bonpland 1455* (F, frag. of type collection of *Gomphia lucens*); Puerto Colombia near Barranquilla, *Elias 919* (NY); Puerto Colombia, *Paul 919* (F).

Riley in his original description of *O. isthmica*, states that the anthers are 9; this is undoubtedly either a miscount or it represents an odd number which was encountered in an abnormal flower; the number of stamens in *Ouratea* are markedly constant in number, viz., ten. Riley, in citing *Hayes 466* (NY) as *O. isthmica* neglects to describe the fruit; the torus of the fruit is compressed-rotund to somewhat compressed obovate, smooth, scarcely coriaceous, and its pedicels are sharply ascending.

O. lucens is closely related to *O. guatemalensis* although its buds are considerably larger and the leaf-blades are more constant in shape.

24. OURATEA GUATEMALENSIS Engler in Mart. Fl. Bras. **12**(2): 345. 1876.

Gomphia nitida Hemsl. Biol. Veg. Bot. **1**: 176. 1879. Not Sw.
Stenouratea wrightii van Tieghem, Ann. Sci. Nat. VIII. **16**: 219. 1902.
Ouratea peckii Riley, Bull. Kew 109. 1924.
Ouratea stenobotrys Riley, Bull. Kew 109. 1924.
Ouratea wrightii (van Tieghem) Riley, Bull. Kew 110. 1924.

Type Locality: Guatemala.
Distribution: Known from Mexico, British Honduras, Honduras, Guatemala, Costa Rica, and Panama.

MEXICO: Without locality, *Matuda 00386* (NY); Chiapas, Tabasco: Balancan, *Matuda 3151* (NY); Oaxaca: Cafetal Concordia, *Morton* & *Makrinius 2698* (F). BRITISH HONDURAS: Yucatan Peninsula, Maskall, *Gentle 1155* (NY), *1256* (NY); Stann Creek Valley, *Gentle 3214* (NY), *3524* (NY); Freshwater Creek, *Heyder* & *Kinlock 34* (F); Temash River, Cornejo Creek, *Kinlock 32* (F). HONDURAS: Colon: Garunta, *von Hagen* & *von Hagen 1313*, *1311* (NY). GUATEMALA: Without locality, *Friedrichsthal 9679* (F, photo & frag. of type collection of *O. guatemalensis*); Petén: Uaxactun, *Bartlett 12240* (NY); Izabal: Puerto Barrios, *Standley 73067* (F). COSTA RICA: Alajuela: Santiago & San Ramōn, *Brenes 6469* (?) (F). PANAMA: Torosi (?), *Mell* s.no. (NY); Penonome: *R. S. Williams 577* (NY); Canal Zone, Barro Colorado Island: *Shattuck 243* (F); *Wetmore* and *Abbe 127* (F), *141* (F); *Wilson 53* (NY), *158* (F); *Woodworth* & *Vestal 389* (F), *509* (F), *617* (F); Bocas del Toro: Bocas Island, *C. P. Cooper 465* (NY).

After a study of more than thirty collections, including a photograph and fragment of the type collection, as well as an analysis of the original descriptions made by Riley, I decided to maintain a single species, *O. guatemalensis*. Not only does Riley fail to offer substantial differentiating characters but he bases his trio of species on a paucity of material. While the wholesale reduction to synonymy of these species makes it easier for

workers, *O. guatemalensis*, as I define it, is not an unnatural species. Its inflorescence, unbranched (or rarely with very short basal branches) and lax, offers a strong distinguishing character.

25. OURATEA MADRENSIS Riley, Kew Bull. 364. 1924.

Type Locality: Sierra Madre, Guerrero, Mexico.

Distribution: Known only from the States of Tabasco and Guerrero, Mexico.

MEXICO: Tabasco: Balacan, S. Isidro, *Matuda 3371* (NY).

Although I have not seen type material of this species, Matuda's collection which is cited above as lying about 500 miles to the east of the type collection, matches Riley's original description in every detail. Since the type collection lacked fruit, I am supplying the following description which is based on *Matuda 3371* (NY): the pedicels lustrous, slender, less than 1 mm. wide, the torus compressed-rotund, wider than long (averaging 8 mm. in width, 5 mm. in length), the drupes obovate-oblong, about 9 mm. long, drying black. *O. madrensis* possesses a strict inflorescence with the fascicles of flowers being borne on definite peduncles; this readily distinguishes it from *O. guatemalensis* to which it is obviously related.

26. OURATEA PODOCARPA Sprague and Riley, Kew Bull. 364. 1924.

Type Locality: Penonome, Panama.

Distribution: Known only from the type locality.

PANAMA: Penonome, *R. S. Williams 223* (NY, type collection); Bismarck above Penonome, *R. S. Williams 546* (NY).

Further collection will be necessary to evaluate this species properly as it is closely related to *O. guatemalensis* in many characters, and may prove, when adequate material is available for study, to be conspecific. The flower buds which are subacuminate at the apex, seem to represent a reliable distinguishing character.

27. **Ouratea prominens** Dwyer, sp. nov.

Virgae obscuro-brunneae laeves; petioli 2–4 mm. longi; folia terminalia, 1.5–3 cm. distantia salicina atque angusto-lanceolata, 9–14 cm. longa, 2.5–3.5 cm. lata, gracili-coriacea vel submembranacea apice acuta basi cuneata, costa supra prominula (ad basim plana) infra prominente, venis secundariis prominulis vel evidenter supra immersis, duorum generum, alibus (10–15) conspicuioribus et evidenter supra prominentibus arcuato-ascendentibus, 0.3–1 cm. juxta costam distantibus, venibus inferioribus margini secundum mediam foliorum laminam appropinquantibus, alibus (numerosissimis) non argute ascendentibus prominulis ramosis obscurum dispositis, margine distincte revoluto serrato dentibus minoribus; stipulae deciduae; floribus et bracteis non visis; rhachidibus (hic in fructu) terminalibus vel axillaribus gracilibus simplicibus superioribus laminis foliorum

brevioribus, circ. 3–4 mm. longis, circ. 1 mm. (basi) latis, floribus solitariis vel fasciculatis articulationibus et sympodiis persistentibus, 1–2.5 mm. longis, saepe in latitudine rachidibus aequis, pedicellis (hic in fructu) evidenter paullum rhachidibus crassioribus vix arcuatis, 10–12 mm. longis, toro persistente globoso aut oblongo-rotundo, circ. 5 mm. lato.

Type Locality: Santiago & San José de San Ramōn, Costa Rica.

Distribution: Known only from the type locality.

COSTA RICA: Santiago & San José de San Ramōn, *Brenes 6838* (F, type).

O. prominens is marked by its very thin-coriaceous leaf-blades which may be described also as being submembranaceous in texture, and by its very prominent secondary veins on the lower surface of the leaf-blades. I have been unable to relate this species to any of the species included in this paper.

28. OURATEA GUILDINGII (Planch.) Urban, Symb. Ant. **1**: 364. 1899.

Gomphia guildingii Planch. Hook. Jour. Bot. **6**: 12. 1847.
Gomphia pyrifolia Griseb. Fl. Brit. W. Ind. 105. 1859.
Ouratea pyrifolia (Griseb.) Engler in Mart. Fl. Bras. **12**(2): 320. 1876.
Trichouratea guildingii (Planch.) van Tieghem, Ann. Sci. Nat. VIII. **16**: 236. 1902.
Ouratella l'herminieri van Tieghem, Ann. Sci. Nat. VIII. **16**: 290, 1902.
Ouratea l'herminieri (van Tieghem) Urban, Symb. Ant. **5**: 430. 1908.

Type Locality: St. Vincent, West Indies.

Distribution: Panama, Jamaica, Antiqua, Monserrat, Guadeloupe, Martinique, St. Lucia, St. Vincent, Tobago, and Trinidad. According to Engler (loc. cit. p. 321) the species *O. pyrifolia*, listed in synonymy above, occurs in Venezuela.

PANAMA: Cristobal Colón, *Broadway 414* (NY), *546* (NY), *797* (NY). JAMAICA: Bridge Hill, *Harris 6978* (NY). GUADELOUPE: Pigeon, *Duss 2307*, *3689* (NY); Bouillante, *L'Herminier* s.no. (F, frag. of type of *O. l'herminieri*). MARTINIQUE: Without definite locality, *Duss 6* (G), *61383* (NY). TOBAGO: Logwood, *Broadway* s.no. (NY); Mile End Road, *Broadway 2440* (F, NY). TRINIDAD: Teteron Bay, *Britton 490* (NY); Without definite locality, *Britton & Hazen 1704* (NY); Chacachacare, *Britton, Freeman & Watts 2687* (NY). VENEZUELA: Miranda, Río Chico, *Jahn 1265* (G).

O. guildingii has oblong-lanceolate leaf-blades borne on angular, often horizontal, light-gray branches; the slender pedicelled flowers are solitary and dense, and terminate the short angular and frequently opposite branches; the inflorescence rarely exceeds the leaf-blades in length. While *Duss 3689* (NY) and *Duss 61383* (NY) have the leaf-blades reaching 11 dcm. in length and have more elongate pedicels, both are referable to *O. guildingii*.

EXCLUDED SPECIES

The following species have been omitted from the body of the paper as I have not seen material of them and since I consider the descriptions to be inadequate.

29. OURATEA FINLAYI (van Tieghem) Urban, Symb. Ant. **5**: 430. 1908.
Ouratella finlayi van Tieghem, Ann. Sci. Nat. VIII. **16**: 290. 1902.

Type Locality: Trinidad? cf. Urban, loc. cit. p. 430 & Symb. Ant. **3**: 47. 1902.

30. OURATEA PODOGYNA J. D. Smith in Bot. Gaz. **17**: 183. 1893.

Type Locality: Pansalma Forest, Alta Verapaz, 1140 m. alt., Guatemala.

This species, according to Riley (loc. cit.), is closely related to *O. gigantophylla* and *O. tuerckheimii*.

31. OURATEA OBLITA Riley, Kew Bull. 108. 1924.

Type Locality: Mexico.

Riley (loc. cit.) relates this species to two other species described in this paper: *O. isthmica* and *O. insulae*. He separates *O. oblita* from these in his key, stating that the leaf-blades of *O. oblita* are "not or very short acuminate" at apex, while those of the latter are "strongly acuminate" at the apex.

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Studies in the Geoglossaceae of Yunnan*

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Yunnan, the type locality of the genus *Hemiglossum*, seems to possess a geoglossaceous flora of unusual richness. On account of transportation and other difficulties, however, collections have been made only in a few places in this province: Kunming in the east, Cheli in the south, and Tali and its vicinity in the west. Despite such limited collecting, many new and interesting forms were brought to light. For instance, intergrading forms between *Geoglossum glabrum* and *G. nigritum* were discovered. Their discovery raises the question whether it is still proper to retain these two species as distinct. Two 4-spored species of *Microglossum* were also found.

Sinden and Fitzpatrick (Mycologia **22**: 60, 1930) observed that the young ascus of the 4-spored species *Trichoglossum tetrasporum* and *T. velutipes* contains the fundaments of 8 spores. Of these only four develop into spores, whereas the others finally become either 4 indistinct protoplasmic strands or 4 small subhyaline spores. These authors also suggested that *T. tetrasporum* arose from *T. hirsutum* or from a common ancestor with 8-spored asci. A similar condition was found by the present writer in the 4-spored species, *Trichoglossum yunnanense*, and in the normally 8-spored species, *T. kunmingense* and *Leotia chlorocephala*. He concurs with them in the suggestion that the 4-spored species are derived from the 8 spored ones (Fig. 35).

In the following descriptions the measurements and colors of the ascophores are based on fresh material or on notes and colored drawings made from fresh plants.

Microglossum Gillet

M. partitum was reported by Patouillard in 1890 from Tsangshan, Tali, Yunnan (Rev. Myc. **12**: 135, 1890), although recently it has been made a synonym of *Corynetes atropurpureus* by Imai (Ann. Myc. **38**: 273, 1940). Of the four species reported below two are described as new.

Microglossum fumosum (Peck) Dur. Ann. Myc. **6**: 408, 1908.
On ground in woods, Tsangshan, Tali, 7454.**

Microglossum olivaceum (Pers.) Gill. Disc. Fr. 25, 1879.
On ground in woods, Kunming, 7414, 7417.

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Microglossum capitatum sp. nov.

Figs. 2, 17

Ascomatibus 3–3.5 cm. altis; clavula capitata, plus minusve compressa, longitudinaliter sulcata, "smoky yellow" (M. & P. 13L6), 1 cm. alta, 0.8–1.2 cm. lata; stipite tereti, glabro, 2–2.5 cm. longo, 3–5 mm. crasso, concolore, fibroso; ascis angustato-clavatis, 137–169×12–14μ, tetrasporis; sporidiis cylindraceis, hyalinis, levibus, curvatis, 69–89×4–5μ, (13–15?) septatis; paraphysibus filiformibus, hyalinis, flexuosis v. leniter curvatis, sursum leniter incrassatis.

Type: on ground, Cheli, Yunnan, August 10, 1939, H. S. Yao, 7422; 8051 from same locality.

The plants are clustered. The ascigerous portion is little distinct from the stipe which is of the same color or of a darker shade than the former. The smoky yellow color and capitate ascigerous portion and larger asci and spores distinguish this species from the following, *M. tetrasporum.*

Microglossum tetrasporum sp. nov.

Figs. 1, 16

Ascomatibus clavatis, 2.5–6 cm. altis; clavula elliptica, "dark beaver" (M. & P. 15A10), compressa, sulcata, convoluta, 1.0–2.5 cm. longa, 6–15 mm. lata; stipite compresso v. tereto, concolore sed paullo dilutiore (M. & P. 15E11), 4–6 mm. crasso; ascis clavatis, 74–123×11–13μ, tetrasporis; sporidiis cylindraceis, curvatis, primo continuis, demum 11–17-septatis, hyalinis, levibus, 49–72×4.3–5.7μ; paraphysibus filiformibus, hyalinis, ramosis, sursum curvatis v. uncinatis, apicibus ellipsoideis v. clavatis.

Type: on ground, Cheli, August 20, 1939, H. S. Yao, 7423.

This species differs from *M. capitatum* microscopically by its brown clavate ascigerous portion and microscopically by its smaller asci and spores, and from the other species of *Microglossum* by its four-spored asci.

Gleoglossum Durand

Gleoglossum glutinosum (Pers.) Dur. Ann. Myc. **6**: 419, 1908.

On ground in woods, Kunming, 7413. Bintsuan, 7421. Cheli: 8052, 8053, 8054. The Yunnan plant is smaller in size (2.5 5 cm. high), and the spore has a smaller range in length (81–97μ).

Geoglossum Pers. emend. Dur.

Geoglossum elongatum sp. nov.

Figs. 10, 32

Ascomatibus 1.2–10 cm. altis, clavatis; clavula piriformi-elliptica, angustate elliptica v. oblonga, 3.5–10 mm. longa, 1.0–4 mm. crassa, plus minusve compressa, atra; stipite tereti v. plus minusve compresso, squamu-

loso, 0.7–1.5 mm. crasso (plerumque 1 mm.), brunneo-atro; ascis clavatis, 125–194×16–22μ, octosporis; sporidiis parallele positis, cylindraceis, 7-septatis, fuligineis, rectis v. curvatis, 64–104×4.5–6.0μ; paraphysibus septatis, cellula terminali clavata, rare globosa, curvatis v. circinatis, brunneolis.

Type: on ground or on fallen leaves and twigs in woods, Shishan, Kunming, July 3, 1938, Jen Hsu, 7420; 7440, 7444, 7439, 7455, 8243 from same locality. Chichushan, Bintsuan, 7437, 7415, 7438, 7421. Tsangshan, Tali, 7441, 7451.

The shape of the paraphyses of this species is quite variable. Paraphyses are often closely septate or, quite rarely, have globose terminal cells.

This species differs from *G. nigritum* by its cylindrical and longer spores, and from *G. glabrum* by its cylindrical and narrower spores and different paraphyses. Macroscopically, collection No. 7415 is exceptional by being ribbon-like, but is microscopically identical with the other collections.

Geoglossum glabrum Pers., var. **angustosporum** var. nov.

Sporidiis 67–89(79–84)×6–7μ; ascis 16–19 latis, aliter ut in forma typica.

Ascomata 5.5–9 cm. high; ascigerous portion lanceolate, compressed, 2–2.7 cm. long, 2.5–5 mm. wide, $\frac{1}{4}$–$\frac{1}{3}$ of the total length, not sharply distinct from the stipe, black; stipe terete or compressed, 1.5–2 mm. thick, brownish black, squamulose or smooth. Asci clavate-cylindrical, shortly stipitate, 150–200×16–19μ, 8-spored; spores in a parallel fascicle in the ascus, clavate, fuliginous, 7-septate, usually slightly curved, 67–89(79–84)×6–7μ; paraphyses closely septate near the apex, the terminal cells abruptly enlarged, moniliform, constricted at septum, brown above, straight or curved.

This variety differs from the species by its shorter and narrower spores and narrower asci.

Type: on ground in woods, Chichushan, September 18, 1938, C. C. Cheo, 7424; 7449, 7418, 7450 from same locality.

Geoglossum nigritum is separated from *G. glabrum* mainly by the remotely septate and scarcely moniliform paraphyses, and the smaller asci and spores. In studying the Yunnan collections the writer found intergrading forms which could not be placed in either of the species. It might, therefore, be well to include *G. nigritum* in *G. glabrum*, the latter name to apply to all the brownish black or black Geoglossums with brown, 7-septate spores and free, brown, septate paraphyses.

GEOGLOSSUM NIGRITUM Cooke, Mycogr. 205, pl. 96, fig. 345, 1878.

On ground in woods, Kunming, 7419, 7445. Chichushan, 7448, 5311. Tali, 7446, 7447. Cheli, 8064.

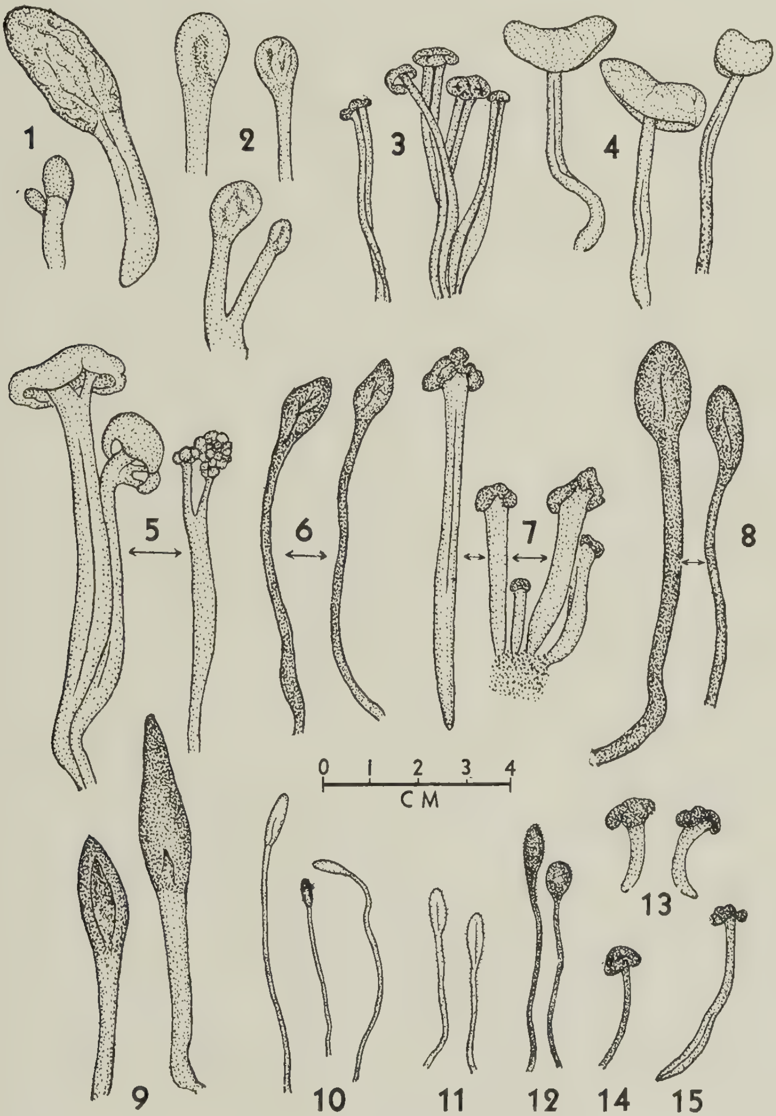

PLATE 1.—1. *Microglossum tetrasporum*. 2. *Microglossum capitatum*. 3. *Leotia kunmingensis*. 4. *Cudonia helvelloides*. 5. *Leotia portentosa*. 6. *Trichoglossum yunnanense*. 7. *Leotia aurantipes*. 8. *Trichoglossum longisporum*. 9. *Trichoglossum sinicum*. 10. *Geoglossum elongatum*. 11. *Geoglossum Durandii*. 12. *Trichoglossum gracile*. 13. *Leotia atro-virens*. 14. *Trichoglossum Persoonii*. 15. *Leotia gracilis*.

Geoglossum nigritum Cooke, var. **Cheoanum** var. nov.

Sporidiis 7–8.5 latis; ascis 175–212×19–25μ; aliter ut in forma typica.

Type: on ground, Hsiakuan, Yunnan, August 21, 1938, C. C. Cheo, 7442.

This variety differs from the species by its much broader and longer asci and wider spores. It is distinct from *G. glabrum* by its shorter spores and different paraphyses.

GEOGLOSSUM FALLAX Dur. Ann. Myc. **6:** 428, 1908.

On ground in woods, Shishan, Kunming, 7416.

GEOGLOSSUM SUBPUMILUM Imai, Trans. Sapporo Nat. Hist. Soc. **13:** 179, 1934. (Figure 33).

On ground in woods, Tali, 7443. Kunming, 8246.

GEOGLOSSUM UMBRATILE Sacc. Mich. **1:** 444, 1878.

Plants 4.5–5.5 cm. high clavate; ascigerous portion lanceolate, not sharply distinct from the stipe, compressed, about ½ of the total length, "sepia" (M. & P. 8A10), 2–2.3 cm. long, 3–3.5 mm. thick, longitudinally furrowed; stipe compressed, slightly tapering towards the base, 2–2.5 mm. thick, densely squamulose, "Mandalay Friar+" (M. & P. 8L12); asci clavate, short-stalked, narrowed at apex, 129–160×16–20μ, 8-spored, multiseriate; spores remaining hyaline for a long time, becoming brownish olivaceous, straight or slightly curved, 3–9-, mostly 7-septate, subcylindrical, 64–81×6–7μ; paraphyses longer than asci, slender, slightly and gradually thickened above, much coiled and twisted at the tip, branched, usually remotely septate, brownish.

On ground under Quercus, Shishan, Kunming, 8247.

G. Barlae Boud. and *G. umbratile* Sacc. are the two species of *Geoglossum* which have 7-septate spores and much coiled and twisted paraphyses. Collection No. 8247 differs from *G. Barlae* in its much smaller asci and smaller spores, but resembles closely *G. umbratile* to which it is tentatively referred.

Geoglossum pusillum sp. nov.

Fig. 23

Ascomatibus 9–13 mm. altis; parte ascigerante elliptica v. late ovata, plus minusve compressa, 4–5 mm. longa, 2–3 mm. lata, atra; stipite tereti, squamuloso, 5–8 mm. longo, 1–1.5 mm. lato, atro-brunneo; ascis clavato-cylindraceis, apice rotundatis v. leniter contractis, 200–227×18–23μ, octosporis, rare tetrasporis; spiridiis cylindraceo-clavatis, olivaceo-brunneis, 11–15-septatis, rectis v. curvatis, 111–144×5–6μ; paraphysibus anguste clavatis v. clavatis, brunneolis, remote septatis, cellula terminali cylindrica v. clavata, 21–51×4–7μ.

Type: on ground, Taiho, Kiangsi, 1937, Hsing-mei Yang, Chekiang University Plant Pathological Herbarium No. 694.

This species differs from *G. pygmaeum* by its smaller ascomata, larger asci, different paraphyses and variable septation of the spores; from *G. pumilum* in the smaller asci and longer spores; and from *G. subpumilum* in the longer asci, longer spores of different shape, and different paraphyses.

Trichoglossum Boudier

Five species and two varieties of *Trichoglossum* have been reported from China: *T. hirsutum* Pers. (Jour. de Bot. **7**: 343, 1893; Sinensia **5**: 448, 1934), *T. Durandii* Teng (Contr. Biol. Lab. Sci. Soc. **8**: 52, 1932), *T. rotundiformis* (Kawamura) Tai et Wei (Sinensia **4**: 98, 1933), *T. Wrightii* Dur. (Sinensia **5**: 449, 1934), *T. confusum* Dur. (Sinensia **5**: 450, 1934), *T. hirsutum* var. *capitatum* (Pers.) Teng (Sinensia **6**: 186, 1935). Re-examination of the specimens formerly referred to *T. rotundiformis* by Mr. Wei and the writer shows that it is identical with *T. Farlowi*. Regarding *T. hirsutum* var. *capitatum*, *T. Farlowi* var. *rotundiformis* and *T. Durandii*, the specimens of which are not available for study, a comparison of the descriptions leads the writer to the conclusion that *T. hirsutum* var. *capitatum* seems to be *T. hirsutum; T. Farlowi* var. *rotundiformis* apparently is *T. Farlowi;* but *T. Durandii* is a good species. Should this conclusion be correct, up to 1935 only five species (*T. Farlowi*, *T. confusum*, *T. Wrightii*, *T. Durandii*, and *T. hirsutum*) of *Trichoglossum* would have been known from China. In this paper ten species and two varieties are reported. Of these, six species and one variety are described as new. The total number of species and varieties of *Trichoglossum* now known from China is, therefore, thirteen species and two varieties.

In the material examined by the writer, clavate setae with rounded apices are often found in *T. sinicum*, *T. kunmingense* and *T. cheliense* (Fig. 26). Sometimes these clavate setae attain the size and shape of an ascus. They arise among the paraphyses from a hypha, the apex of which is one to three-celled and fuliginous in color. At this stage the seta is hardly distinguishable from the paraphyses except by its fuliginous color. The septation of the mature seta is usually four, but sometimes one, three, five or six. As the seta approaches maturity, it becomes darker and darker, whereas the septa become less and less evident until they disappear entirely.

Key to the Species of Trichoglossum Known from China

1. Spores 45–100μ long 2
   Spores 100–190μ long 3
2. Spores 0–6-septate, clavate-cylindrical .... *T. Farlowi*
   Spores 7-septate, clavate .... *T. confusum*
3. Spores 100–160μ long 4
   Spores 160–190μ long 12
4. Spores 8 in each ascus 6
   Spores 4 in each ascus 5

5. Spores 7–11-septate . . . . . . *T. velutipes*
Spores 15-septate, 117–136μ long . . . . . . *T. tetrasporum* var. *brevisporum*
6. Spores 15-septate 7
Spores 7–12-septate 10
7. Spores cylindrical-clavate . . . . . . *T. hirsutum*
Spores clavate-cylindrical 8
8. Spores with one end blunt and the other slightly pointed; ascomata densely velvety or not . . 9
Spores with pointed ends; ascomata not densely velvety . . . . . . *T. gracile*
9. Spores brown; ascus 200–231$\times$18–22μ; stipe densely velvety, black . . . . . . *T. cheliense*
Spores pale brown, remaining hyaline for a long time; ascus 175–212$\times$16–19μ; stipe and ascigerous portion conspicuously hairy, light cinnamon brown or Verona brown when fresh, black when dry . . . . . . *T. Durandii*
10. Spores 7-septate, subcylindrical . . . . . . *T. kunmingense*
Spores 8–12-septate 11
11. Spores 8–9-septate, rarely 5, 6 or 7 . . . . . . *T. Wrightii*
Spores 8–12-septate . . . . . . *T. hirsutum* f. *variabile*
12. Spores 8 in each ascus, rarely 4; 15-septate 13
Spores 4, rarely 2 or 8; 15-septate . . . . . . *T. yunnanense*
13. Spores 5–6μ wide, with sharply pointed ends . . . . . . *T. Persoonii*
Spores 6–7μ wide, with obtuse ends 14
14. Spores 147–175μ long; stipe "wood rose" (sorghum brown); setae short and slender (6–7μ wide) . . . . . . *T. sinicum*
Spores 156–190μ long; stipe densely velvety and black; setae long and stout (10–13μ wide) . . . . . . *T. longisporum.*

TRICHOGLOSSUM HIRSUTUM (Pers.) Boud. Bull. Soc. Myc. Fr. **1**: 110, 1885.

On ground in woods, Kunming, 5084. Tali: 5263, 5087, 5093, 5262, 5090. Chichushan: 5086, 5264, 5260, 5261, 5094.

The writer includes in *T. hirsutum* all forms which have a dull black ascigerous portion, densely velvety and black stipe, and cylindrical-clavate, 15-septate spores that are about 100 to 160μ long and 6 to 7μ broad. The shape and size of the ascigerous portion, both of which vary greatly, could not be used as criteria for distinguishing species.

TRICHOGLOSSUM HIRSUTUM (Pers.) Boud. f. VARIABILE Durand, Ann. Myc. **6**: 437, 1908.

Cheli: 8055, 8056, 8058, 8073, 8244.

This form differs from *G. Wrightii* by its shorter and narrower asci, narrower spores and the larger number of septa. The number of septa in the spores is quite variable; thus, in collection No. 8055 the majority of the spores are 7-septate, in 8056 8-septate, in 8073 and 8058, 10–11-septate.

TRICHOGLOSSUM GRACILE Pat. Bull. Soc. Myc. Fr. **25**: 131, 1909.

Figs. 12, 34

Ascomata 1.8–6 cm. high, conspicuously hairy, black when dry; ascigerous portion rotund, rarely elliptic, rounded, rarely slightly compressed, about $\frac{1}{8}$ to $\frac{1}{5}$ of the total length, distinct from the stipe when fresh, 2–4 mm. in diameter, black; stipe slender, flexuous, equal, 0.5–1.0 mm. thick, "café noir" when fresh, black when dry, terete; asci clavate-cylindrical, 168–237$\times$16–19μ; spores 8, clavate-cylindrical, slightly tapering from the middle, more or less pointed at the ends, 15-septate, brown, 110–162

(126–156)×5–6μ; paraphyses pale brown or brown, slightly thickened at apex, curved or uncinate, septate, often branched at the base; setae projecting about $\frac{1}{3}$ to $\frac{1}{2}$ of their length above the hymenium, 8.5–14μ wide.

On ground in woods, Kunming: 5083, 5078, 5080, 5082, 5097, 6884. Chichushan: 5081, 5096.

This species differs from *T. hirsutum* by its conspicuously hairy ascoma, slender stipe, clavate-cylindrical and narrower spores and narrower asci, but agrees closely with the description of *T. gracile* Pat. and is tentatively referred to this species.

TRICHOGLOSSUM DURANDII Teng, Contr. Biol. Lab. Sci. Soc. **8**: 52, 1932.

Figs. 11, 31

Ascomata 2.5–4 cm. high, clavate, conspicuously hairy, entirely and densely covered with black hairs, light cinnamon brown or Verona brown when fresh, becoming black when dry; ascigerous portion elliptic or lanceolate, 0.8–1 cm. long, 2–2.5 mm. wide, more or less compressed, not distinct from the stipe; stipe 1.5–3 cm. long, about 1 mm. wide, conspicuously hairy as in the ascigerous portion, terete, straight or more or less flexuous; asci clavate, 175–212×16–19μ, 8-spored; spores clavate-cylindrical to subcylindrical, with one end blunt and the other slightly pointed, remaining hyaline for a long time, finally becoming brownish, mostly 15- sometimes 12–14-septate, 117–129×5–6μ; paraphyses clavate, thickened at the tip, the terminal cell brownish or subhyaline, septate, straight or slightly curved; setae projecting one third or usually one half or more of their length above the hymenium, 10–14μ wide, black.

Cheli: 5312, 5313, 6883, 8050, 8074.

This species is distinct from *T. cheliense* by its conspicuously hairy ascomata, shorter and narrower asci and paler spores. It is very close to *T. Durandii* Teng except that the plants are larger and not whitish, and that the spores are mostly 15-septate. The specimens on which Teng based his original diagnosis may be immature.

Trichoglossum cheliense sp. nov.

Fig. 24

Ascomatibus 3–6 cm. altis, clavatis, simplicibus v. bifurcatis; clavula elliptica, rotundata v. furcata, compressa 0.5–1.4 cm. alta, 5–10 mm. crassa, brunneo-atra; stipite tereti v. compresso, hirsuto, atro, 3–4.5 cm. longo, 1.5–3 mm. crasso; ascis clavatis, 200–231×18–22μ; 8-sporis; sporidiis clavato-cylindraceis v. subcylindraceis, 15- raro 13–14-septatis, brunneis, 89–151 (104–132)×5–6μ; paraphysibus septatis, sursum brunneis v. pallide brunneis, uncinatis, leniter incrassatis.

Type: Cheli, August 1939, H. S. Yao, 6885; 5316, 8065, 8066 from same locality. The specimens of collection No. 6886 are lobed, while those of No. 5316 are not. Microscopically they are identical.

This species is closely related to *T. hirsutum* but is distinct by its subcylindrical and narrower spores.

Trichoglossum kunmingense sp. nov.

Fig. 26

Ascomatibus 1.5–3.5 cm. altis; clavula lanceolata v. elliptica, compressa, 5.5–8 mm. longa, 3–4 mm. crassa, brunneo-atra; stipite tereti v. compresso, 2–3 mm. crasso, hirsuto, atro; ascis clavatis, $175–225 \times 19–25\mu$, 4 v. 8-sporis, plurimis 8; sporidiis clavato-cylindraceis v. subcylindraceis, brunneis, 7- raro 3–6-septatis, 104–144 (plurimis 117–123) $\times 6–8\mu$; paraphysibus uncinatis, brunneis, septatis.

Type: on ground in woods, Shishan, Kunming, August 9, 1938, F. L. Tai and H. S. Yao, 5095; 5091, 5092, 6363 from same locality.

This species differs from *T. Walteri* mainly by its longer spores.

Trichoglossum yunnanense sp. nov.

Figs. 6, 29

Ascomatibus 3.5–7.5 cm. altis; clavula elliptica v. subglobosa, compressa, atra; stipite 4.5–7 cm. longo, 2–3 mm. crasso, tereti, flexuoso, atro; ascis cylindraceo-clavatis, 4- raro 2 v. 8-sporis, $237–294 \times 19–22\mu$; sporidiis clavato-cylindraceis, 15- (raro 16)-septatis, brunneis, $143–187 \times 6–7\mu$; paraphysibus brunneis, septatis, clavatis, sursum curvatis.

Type: on ground in woods, Chichushan, September 18, 1938, C. C. Cheo, 5393; also deposited in the Plant Pathology Herbarium, Cornell University as No. 27985.

This species is very close to *T. longisporum* except that the number of spores per ascus is eight in the latter. It differs from *T. tetrasporum* by its longer and narrower asci, longer ascospores and by the shape of the spores.

Dr. W. L. White of Cornell University, who has kindly compared this plant with the type specimen of *T. tetrasporum*, considers it as a form of *T. hirsutum* from which it is, however, distinct by 2- or 4-spored longer asci and spores.

Trichoglossum Persoonii sp. nov.

Figs. 14, 25

Ascomatibus 2.5–4 cm. altis; clavula abrupte subglobosa v. ovata, rotundata, 5–9 mm. alta, 3–8 mm. lata, atra; stipite tereti, 1–3 cm. longo, 1–2 mm. crasso, atro-brunneo; ascis clavatis, $225–275 \times 18–23\mu$, 8-sporis; sporidiis clavato-cylindraceis, 13–20-septatis, plurimis 15–19, gracilibus, $162–200 \times 5–6\mu$, brunneis, rectis v. curvatis, paraphysibus clavatis, brunneolis, septatis, sursum incrassatis, rectis v. curvatis, apicibus non v. cohaerentibus, supra ascos epithecium brunneum formantibus.

Type: on ground in woods, Cheli, August, 1939, H. S. Yao, 8067; 8068, 8070, 8075, 8096, 8071 from same locality.

PLATE 2.—16. *Microglossum tetrasporum*. 17. *Microglossum capitatum*. 18. *Leotia kunmingensis*, note long and slender stipe of ascus. 19. *Leotia atro-virens*, note branching of paraphyses. 20. *Leotia gracilis*, note variability of paraphyses. 21. *Cudonia helvelloides*. 22. *Leotia portentosa*. 23. *Geoglossum pusillum*.

This species is distinct from *T. gracile* by its longer and broader asci, and longer spores, and from *T. longisporum* by narrower spores, and from both by its sharply pointed spores.

The paraphyses are not always agglutinated. Agglutination of the paraphyses is variable and apparently not a dependable character for differentiating species.

In appearance this plant with its abruptly subglobose fertile portion

resembles very much those illustrated by Lloyd under the name of *Geoglossum capitatum* (see his "The Geoglossaceae," 1916, fig. 794). But since no detailed description was given, it could not be ascertained that Lloyd's plant is identical with ours.

This species is distinct from all species of *Trichoglossum* by its sharply pointed spores and agglutinated paraphyses. It might be identical with *G. capitatum* Pers., but in the absence of authentic specimens and in view of the incomplete description Persoon's species is poorly known. It seems best to describe this Chinese plant as a new species.

Teng's *T. hirsutum* var. *capitatum* (l.c.) should be included in *T. hirsutum*, since it differs only by its subglobose ascigerous portion.

Trichoglossum sinicum sp. nov.

Figs. 9, 27

Ascomatibus clavatis, 5.5–7 cm. altis; clavula lanceolata, compressa, atra, 2.5–3 cm. longa, 0.8–1 cm. crassa; stipite tereti, saepe parum compresso et sulcato, 3–4 cm. longo, 3.5–5 mm. crasso, "wood rose sorghum brown" (M. & P. 6B9); ascis clavato-cylindraceis, $237–281 \times 21–26\mu$, octosporis, raro 4-sporis; sporidiis cylindraceo-clavatis, 7–15-septatis, plurimis 15, $147–175 \times 6–7\mu$, brunneis; paraphysibus clavatis, septatis, apicibus brunneis.

Type: Cheli, August, 1939, H. S. Yao, 5315.

The size and color recorded above are based on the colored drawings and notes made by Mr. H. S. Yao. The setae of the plant are unusually slender and short, mostly shorter than the asci, not or hardly projecting above the hymenium, $6–7\mu$ wide. The number of the septa of the spore varies from 7 to 15, but is mostly 15. This species is distinct from all other species of *Trichoglossum* in its robust, light colored stipe. It is close to *T. longisporum*, but differs by its robust, nonvelvety light colored stipe and shorter spores. It is also distinct from *T. hirsutum* by its longer and broader asci, slightly longer spores and different stipe.

Trichoglossum longisporum sp. nov.

Figs. 8, 30

Ascomatibus 5.5–10 cm. altis; clavula elliptica v. subglobosa, 1–2 cm. alta, 5–12 mm. crassa, parum et irregulariter compressa, atra; stipite tereti, flexuoso, 1.5–3 mm. crasso, atro, hirsuto; ascis clavato-cylindraceis, $237–281 \times 19–25\mu$, 8-sporis, sporidiis clavato-cylindraceis, $156–190 \times 6–7\mu$, 15 (raro 7 v. 13)-septatis, brunneis; paraphysibus pallide brunneis, uncinatis, septatis.

Type: Chichushan, September 18, 1938, C. C. Cheo, 5089.

This species differs from *T. hirsutum* by its longer and broader asci and spores. It is very close to *T. yunnanense* except that the asci are regularly 8-spored.

Trichoglossum tetrasporum Sind. & Fitzpatr., var. **brevisporum** var. nov.

Fig. 28

A typo sporidiis 117–136μ longis differt.

Ascomata 2–3 cm. high; ascigerous portion subrotund, separated abruptly from the stem, about $\frac{1}{4}$ of the total length, dull black; stipe terete, about 1 mm. broad, densely velvety, black. Asci cylindrical-clavate, 206–219$\times$19–24μ, 4-spored, rarely 2; spores cylindrical-clavate, straight or slightly curved, brown, 15-septate, 117–136$\times$6–7μ; paraphyses slightly thickened at apex, septate, pale brown, curved; setae projecting $\frac{1}{4}$ to $\frac{1}{3}$ of its length above the hymenium, 10–11μ wide.

Type: Chunghosze, Tali, August 24, 1938, H. S. Yao, 5085.

This plant is close to *T. tetrasporum* except that its spores are shorter. The asci are usually 4-spored, but 2-spored asci in the type of *T. tetrasporum*, a fragment of which was kindly sent by Dr. W. L. White.

TRICHOGLOSSUM VELUTIPES (Pk.) Dur. Ann. Myc. **6**: 434, 1908.

Ascomata 4–4.5 cm. high; ascigerous portion lanceolate or elliptical, distinct from the stipe, $\frac{1}{5}$–$\frac{1}{4}$ of the total length, simple or furcate, 0.7–1 cm. long, 0.6–1 cm. thick, more or less compressed, black; stipe terete, more or less flexuous, 3.0–3.2 cm. long, 2–4 mm. wide, tapering below, velvety, black; asci clavate, somewhat narrowed at apex, very short-stiped, 188–224$\times$17–22μ, 4-spored; spores narrowed each way from the middle, 7–12, mostly 10–11-septate, 106–154$\times$5.5–6.5μ, olivaceous brown; paraphyses variable in shape, clavate, slightly curved or uncinate at apex, brownish, hyaline below, septate; setae 117–157$\times$6–7μ (broadest part).

Cheli: 8061, 8063.

LEOTIA Pers.

Leotia aurantipes (Imai) stat. nov.

Fig. 7

L. lubrica f. *aurantipes* Imai, Bot. Mag. Tokyo **50**: 9–16, 1936.

Plants solitary or gregarious, 2–8.5 cm. high, somewhat viscid-gelatinous; ascigerous portion pileate, convex, irregularly furrowed, 4–6.5 mm. high, 4–12 mm. broad, dark green (M. & P. 16H3), olivaceous green (M. & P. 23C1), yellowish olivaceous green (M. & P. 21B1) or brown (M. & P. 12L10); stipe terete when young or just beneath the ascigerous portion, usually compressed below, hollow, yellow (M. & P. 12L7) or orange yellow (M. & P. 11G5 or 11L8), usually slightly tapering above, more or less enlarged at the lower half and then slightly tapering towards the base, longitudinally furrowed, rarely branched at the tip, sometimes twisted, with minute inconspicuous greenish granules, 3–8 cm. long, 1.5–3.0 mm. wide above, 3–5 mm. wide below; asci clavate-cylindrical, slightly narrowed at the apex, 119–162$\times$8.6–12μ; spores 8, biseriate above, uni-

seriate below, fusoid, with obtuse or subacute ends, straight or slightly curved, hyaline, becoming 3–7-septate, 17–23×5.0–6.4μ; paraphyses filiform, branched at the base, hyaline, septate, apices clavate or abruptly piriform or globose, straight or somewhat curved.

On ground in woods, Kunming: 7430, 7431, 7432, 7436, 7461, 7840, Chichushan: 7433, 7434, 7435, 7429.

L. aurantipes is easily distinguished from the other species of *Leotia* by its dark green, olivaceous green or somewhat ochraceous yellow head and orange yellow stipe. It is the most common species around Kunming. Kawamura gave an excellent colored illustration of this species in his "Japanese Fungi" (fig. 4, 1929) under the name of *L. lubrica.*

Since the type of *L. lubrica* does not exist, this species has been variously interpreted by different authors. Thus, Massee (Brit. Fung. Fl. **4**: 471, figs. 25–27, 1895) and Durand (Ann. Myc. **6**: 446, figs. 106, 213, 1908) consider the entirely olivaceous, ochraceous-yellow plants as *L. lubrica*, while according to others, notably Gillet (Disc. Fr. p. 23, pl. 102, 1879), Rehm (Disc. p. 1165, figs. 1–4, 1896 as *L. gelatinosa*) and Bresadola (Icon. Myc. **24**: T. 1187, 1932), the latter should have a yellowish green or olivaceous brown ascigerous portion and a yellow stipe. Imai (Bot. Mag. Tokyo **50**: 9–16, 1936) maintains that it is more reasonable to designate the gelatinous *Leotiae* which have mainly an ochraceous olive or green tint throughout or in part as the *lubrica* group, and to treat some of the species of *Leotia* as forms of *L. lubrica* rather than to recognize them as distinct species.

On the basis of his field and laboratory study of the forms of Imai's *lubrica* group in Yunnan for the past few seasons, the writer is of the opinion that well marked species can be distinguished in that group and that many of Imai's forms should be raised to specific rank. It is true that these fungi are variable in color, size and form. But when all observable characters and the limits of their variation are taken into consideration, little difficulty would be met in their identification.

Since it is impossible to determine what typical *L. lubrica* is, it is preferable to give new names to the entirely olivaceous ochraceous-yellow plants of Durand and to those with yellowish green or olivaceous brown heads and yellow stipes of Gillet and others, after they have been studied again and compared in fresh condition, rather than to refer them to the old and poorly known *L. lubrica.*

Macroscopically *L. aurantipes* resembles closely *L. lubrica*, as described by Gillet and others, but differs in having usually a compressed stipe and slightly narrower and shorter asci. Whether or not the Kunming plant is identical with that of Gillet could not be determined. But the Kunming plant is undoubtedly identical with the Japanese one designated by Imai

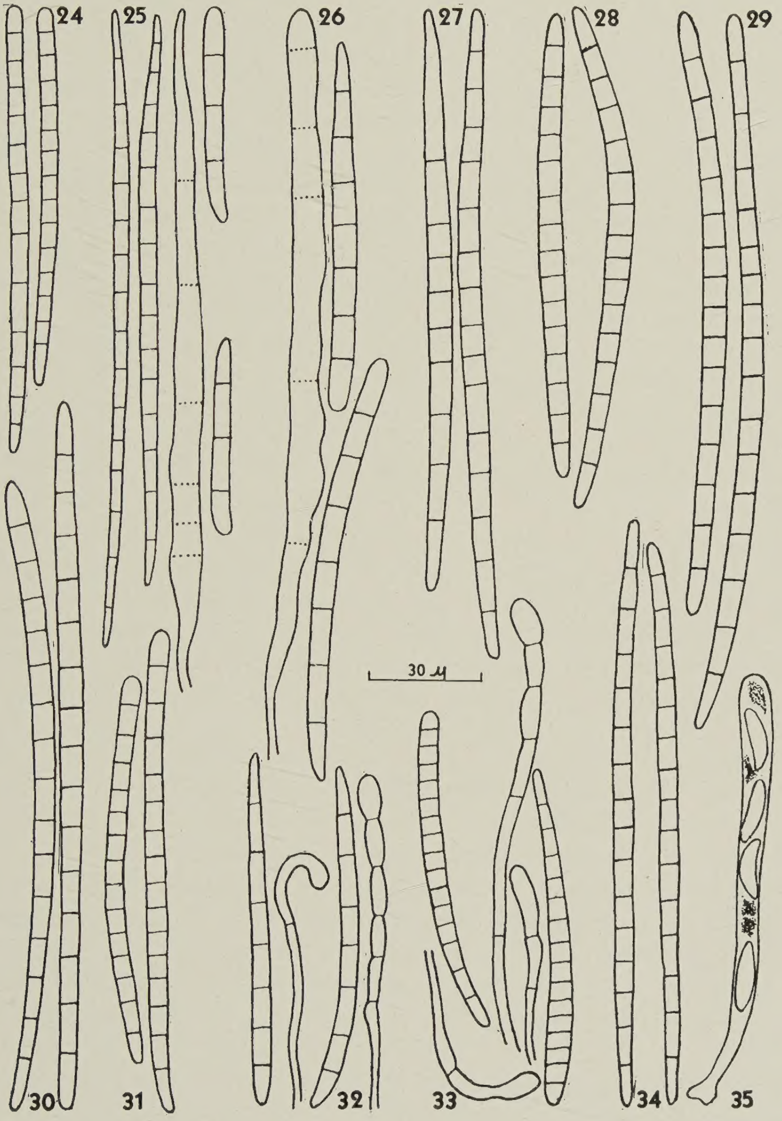

PLATE 3.—24. *Trichoglossum cheliense*, note shape of spore. 25. *Trichoglossum Persoonii*, note sharply pointed ends of spore. 26. *Trichoglossum kunmingense*, note small abnormal spores. 27. *Trichoglossum sinicum*. 28. *Trichoglossum tetrasporum* var. *brevisporum*. 29. *Trichoglossum yunnanense*. 30. *Trichoglossum longisporum*. 31. *Trichoglossum Durandii*. 32. *Geoglossum elongatum*. 33. *Geoglossum subpumilum*. 34. *Trichoglossum gracile*. 35. *Leotia chlorocephala*, note disintegration of four of the eight spores.

as *L. lubrica* f. *aurantipes*, to which it is here referred. Even if it were found to be identical with the European form described by Gillet and others, it should nevertheless have a new name for the above reasons.

Leotia kunmingensis sp. nov.

Figs. 3, 18

Ascomatibus gregariis, viscidulis, 4.5–5.5 cm. altis, atro-viridibus; parte ascigerante convexa, irregulariter sulcata, 0.5–1 cm. lata, 1.5–5 mm. alta, atro-viridi (M. & P. 24H5); stipite compresso, longitudinaliter sulcata, plus minusve contorto, 4–5 cm. longo, aequali v. deorsum incrassato, 2–4.5 mm. lato, glabro, concolore sed paullo dilutiore (M. & P. 23E6), firmo; ascis angustate clavatis, longe pedicellatis, $137–166 \times 8–11\mu$, octosporis; sporidiis elliptico-fusiformibus, hyalinis, rectis v. leniter curvatis, primo continuis, demum 3-septatis, $16–20 \times 5.3–6.4\mu$; paraphysibus filiformibus, deorsum ramosis, rectis, viridulis, septatis, apice subclavatis aut nodulosis, 2μ crassis.

Type: on ground in woods, Shishan, Kunming, August 28, 1938, F. L. Tai, 7452.

In the locality, where the above specimens were collected, abundant material of *L. aurantipes* was also gathered. The dark green plant is evidently not an environmental variation of *L. aurantipes*. *L. atro-virens* is smaller in size and lighter in color, has a non-furrowed and furfuraceous stipe, and paraphyses which are branched near the apex. It is also distinct from *L. chlorocephala* by its darker color, and the firm, compressed and non-furfuraceous stipe.

Leotia portentosa (Imai et Minak) stat. nov.

Figs. 5, 22

L. lubrica f. *portentosa* Imai et Minak, Bot. Mag. Tokyo **50**: 9, 1936.

Plants clustered, 9–13 cm. high, entirely bluish-green to olivaceous green (M. & P. 23L1 or 30B7); ascigerous portion convex, smooth or furrowed, often ramose-lobate, lobes sometimes subtubercular, margin incurved, 1–2.4 cm. broad; stipe terete or more or less compressed, often branched at the tip, 7.5–11 cm. long, 3–7 mm. wide, equal or enlarged at the middle, furfuraceous with green granules, longitudinally furrowed and often twisted, firm. Asci clavate to clavate-cylindrical, apex rounded or slightly narrowed, $103–130 \times 8.6–11\mu$; spores 8, subbiseriate above, uniseriate below, elliptical-fusiform with blunt or subacute ends, hyaline, straight or curved, continuous at first, becoming 5–7-septate, $15–20 \times 5.3–5.7\mu$; paraphyses filiform, hyaline with greenish tint, the apices piriform or clavate, septate, branched near the base, green.

On ground in woods, Chichushan, September 11, 1938, C. C. Cheo, 5194.

Its large size, ramose-lobate clavule and greenish color are the distinguishing characteristics of this species.

LEOTIA CHLOROCEPHALA Schw. ex Durand, Ann. Myc. **6**: 450, 1908.

Fig. 35

On ground in woods, Chichushan, 7427, 7428. Tsangshan 7453.

Imai (l.c.) regarded *L. chlorocephala* as one of the forms of his *L. lubrica*, but proposed a new name for it, *chlorosoma*, rejecting *L. chlorocephala* which had been imperfectly described in the original diagnosis. Since Durand studied the type specimen of Schweinitz and redescribed it, there seems to be no more doubt about its identity.

LEOTIA ATRO-VIRENS Pers. Myc. Eur. **1**: 202, pl. 9, figs. 1–3, 1822.

Figs. 13, 19

Plants 1.3–2.5 cm. high (rarely up to 5 cm. high); ascigerous portion convex, somewhat convoluted, margin incurved, dark green (M. & P. 24C10), 6–11 mm. broad; stipe terete, more or less compressed at the lower two-third, straight, yellowish green (M. & P. 23L2), densely furfuraceous with green granules, almost equal in diameter, sometimes tapering at the lower end, 1–2 cm. long (rarely 4.8 cm.), 2–3 mm. wide. Asci narrowly clavate, shortly stipitate, occasionally with a long and slender stipe, 109–147×6–10μ; spores 8, subbiseriate above, uniseriate below, or uniseriate, elliptical or fusiform-elliptical, hyaline (greenish in mass), straight or curved, continuous at first, becoming 5-septate, 14–24×5.4–6.1μ; paraphyses slightly thickened at apex, straight or flexuous, indistinctly septate, branched near the apex or at the base, hyaline.

On ground in woods, Kunming, 7536, 7538. Meitan, Kweichow, Chekiang University Plant Pathological Herbarium No. 691 (7800).

Among the plants collected by Mr. Chiu on November 12, 1941 (7536), there is one which is 5 cm. high, whose ascigerous portion is 11 mm. in diameter and whose stipe is 4.8 cm. long and 2.5 mm. wide. The stipe is, however, bent and its lower two-thirds lie prostrate on the ground, whereas the above ground portion is only 2 cm. long. Its microscopic characters and color do not differ from the other plants.

Leotia gracilis sp. nov.

Figs. 15, 20

Ascomatibus gregariis, viscidulis, 1.0–4.5 cm. altis, atro-viridibus; parte ascigerante convexa, convoluta, margine incurvata, atro-viridi (M. & P. 24A7), 5–9 mm. lata, laxe granulata; stipite tereto, deorsum plus minusve compresso et interdum incrassato (2 mm.), firmo, furfuraceo, atro-viridi (M. & P. 24A8), 0.8–4 cm. longo, 1–1.5 mm. lato; ascis angustate clavatis, 116–139×9–11μ, octosporis, raro 6; sporidiis elliptico-fusiformibus, hyalinis, rectis v. curvatis, primo continuis, demum 5-septatis, 17–24×5.7–6.4μ; paraphysibus hyalinis, non v. sursum ramosis, septatis, apice clavatis v. irregulariter incrassatis.

Type: on mossy slope, Tienfungan, Kunming, November 11, 1941, W. F. Chiu, 7537.

This species differs from *L. atro-virens* by its slender form and darker color. In addition, the stipe is sometimes enlarged at the basal part, and the spores are more tapering towards the ends than those of the other species. It differs from *L. chlorocephala* by its slender form, darker color, and by its paraphyses which are sometimes branched near the apex.

SPATHULARIA Pers.

SPATHULARIA CLAVATA (Schaeff.) Sacc. Mich. **2**: 77, 1882.

On ground in woods, Tsangshan, Tali, 5194.

CUDONIA Fr.

CUDONIA HELVELLOIDES S. Ito et Imai, Trans. Sapporo Nat. Hist. Soc. **13**: 18, figs. 32–35, 1934.

Figs. 4, 21

Ascomata 4–6 cm. high, pileate, pinkish cinnamon (M. & P. 12C6); ascigerous portion depressed-convex or saddle-shaped, slightly depressed at the center, somewhat furrowed, margin incurved, 6–9 mm. high, 1–2.5 cm. broad; stipe flexuous, concolorous with the pileus, terete or more or less compressed, slightly enlarged towards the base, 3.5–5 cm. long, 2–3 mm. thick, longitudinally furrowed. Asci clavate, much attenuated below, apex slightly narrowed, $121–144 \times 8.6–10\mu$; spores 8, biseriate, clavate-filiform, hyaline, straight or curved, indistinctly septate (7?), $43–63 \times 1.7–2.1\mu$; paraphyses filiform, hyaline, closely septate above, the terminal cells elliptical or globose thickened, slightly or strongly curved.

On ground in bamboo groves, Tsangshan, Tali, August 20, 1938, collected by a workman, 7426.

This collection is referred to *C. helvelloides* with some hesitation, because no authentic specimen of this species has been seen. Spore measurements and other characters agree well with those of the Japanese species except the irregular swelling of the apex of the paraphyses which was not mentioned in the original description of that species.

SUMMARY

This paper records the results of a study of twenty nine species and four varieties of Geoglossaceae found in Yunnan (except one species from Kiangsi), of which twelve species and three varieties are described as new. Intergrading forms between *Geoglossum glabrum* and *G. nigritum* were found. Two of Imai's forms of *Leotia lubrica*, *aurantipes* and *portentosa*, are raised to specific rank. It is suggested that *L. lubrica* be rejected because it has been variously interpreted by different authors.